THE AMERICAN
JOURNAL OF PSYCHOLOGY
Founded by G. Stanley Hall in 1887

Vol. XXV OCTOBER 1914 No. 4

THE DISTRIBUTION OF CONSCIOUSNESS AND ITS CRITERIA

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I

The field of psychology is by definition the system of phenomena which mental life presents. Its aim is to characterize these phenomena and formulate their laws under the ideal of a unitary system within which all descriptive and explanatory concepts shall finally be congruous with one another.

Materials for the psychologist's study are primarily afforded by the facts of his own immediate experience. But this field provides only the starting-point of his general inquiry, which at once carries him across the boundaries of his own mental life into a larger kingdom of minds. For this extension of the field there are at least two reasons. The first is methodological and results from the significance of the observer's attitude in psychological investigation. In order to study the mental content or activity in an unmodified form and under its natural conditions the mind must, so far as possible, be relieved of all other interests and responsibilities at the moment. Its participation in the conduct of the experiment,— such as the immediate control of conditions and presentation of the stimulus— and in the making and checking of records, should be reduced to a minimum. Among these modifying elements none is more significant than the attitude of the subject toward his own experience and its psychological significance; so that, in general, it is equally necessary to avoid an emotional self-consciousness and a reflectively critical atti-

tude on the part of the observer. In many cases this can be secured only when the subject is in ignorance of the nature of the problem under investigation, and of the bearing of his own observation upon its solution. The conditions of experimentation have therefore made it the general practice of the psychologist to seek the assistance of an observer who is both freed from all care of what may be called instrumentation, and kept in an attitude of naïve or primary attention to the observation to be made. This first consideration, therefore, concerns only the difficulties of manipulation when the subject is called upon to control the conditions of his own observation.

The second reason for extending the materials of psychological study beyond the primary field of self-observation springs from the aim of the science itself. For its interest does not terminate with a scrutiny of the subject's own mind as individual and unique. That mind is indeed sufficient in itself to afford a field for psychological study, as various classical researches have shown; for it presents a complex system of correlated phenomena providing problems both of characterization and of explanation. But like all natural sciences psychology looks beyond the individual to series and types; and the object of the psychologist's study is a kingdom of minds to which his own belongs merely as one out of many. These minds are not identical in their forms and modes of activity. They vary individually and fall into groups according to their likenesses and differences. To explore these various mental types and to set forth their characteristic features, to formulate their variations and arrange them as typical groups in an orderly classification is the work of descriptive psychology. It is not personal characterization or individual history but the common features and laws normal to a group of individual minds in which interest centers.

In all this work the psychologist is indeed not brought face to face with his materials. He must reconstruct the form of any function, and of the mental life at large, by the interpretation of series of physical changes,—words, gestures, acts and modifications in material objects. The physical events are all that he directly perceives; the minds themselves lie beyond his field of vision and are discernible only indirectly. This dramatic reconstruction in terms of a significant inner experience we make, of course, quite apart from any scientific interest; and psychology may be said simply to adopt the interpretative reconstruction which common sense has made on the basis of the purposeful system of activities connected with

the human body. It is a general predication of the relation which immediate experience presents. As my own bodily activities express my mental life in the sense of presenting specific correlations with its individual features, I interpret each individual movement of my neighbor's body in terms of a similar mental change.

Psychology thus avoids the metaphysical problem which a criticism of this process of interpretation raises. Mental life is postulated. The problem of real existence and its cognition is not raised. Yet the product of common-sense interpretation cannot be accepted uncritically as the basis of a psychological predication of the existence and range of consciousness. The procedure of common sense is loose; it applies no rigid criterion; it is not consistent in its successive attitudes. The range of significant inner life is now broadened and then restricted as purpose and sentiment change. In the course of these shiftings conflicting criteria are applied at different times, the same process being interpreted now in terms of purpose then in terms of mechanism. At one moment the whole order of nature is made the expression of a significant spirit, at another this form of interpretation is denied even to the subject's own acts.

Psychology cannot accept a principle so loosely applied as the basis of its treatment. Either nature is ensouled and every change occurring therein is expressive of an appreciative inner life, or it is not so. In the first case we are theoretically confronted with the task of formulating the psychology not only of men and brutes but of unicellular animals and plants, not only of living organisms but of inanimate objects and the earth as a whole; for under the assumption in question all these existences are part of that general field with which psychology deals, whether it be accessible to the application of technical methods or not. In our sentimental moods we do thus apply to all changes of nature the concept of a significant life, a life of function and purpose, of sensitivity and appreciation.

The problem, after all, cannot be wholly avoided. In those types whose affiliation with our own is evident and close the problem may not be raised, except in terms of the particular trait of which the physical datum is to be taken as evidence. But when the divergence has increased to a certain extent, when both habit and structure are materially different from our own, it is certain to arise. What limits shall we set to the distribution of mind? Which class of facts shall we accept as the indication of its presence?

To formulate this problem rationally we must approach it with an understanding of the criteria according to which mind is predicated in connection with other physical activities than our own bodies. The argument has been called an analogy; it may also perhaps be called an induction. The alliance of physical and mental we know directly in the case of our own minds and bodies. Each side here is immediately given. The parallelism is not indirectly verified but immediately intuited. Every change in the body is sensed; every intention, every feeling finds expression in a characteristic bodily modification. Nor is the connection a merely general association; it is a point by point correspondence which may be read from either side. Thus, if my meaning is expressed in words, this relation necessitates that my words should have meaning,—that is, the reproduction of the words in their proper order should be capable of reinstating the thought they originally expressed. One thus becomes able to read meaning into words as well as to express meaning through words. And so also with every other factor in this physical correlate of mind; each expression is a symbol for a certain mental content which may indirectly be reached through it.

Now in the physical world there is to be found alongside of the observer's body other similar bodies reproducing his own feature by feature and manifesting the same general system of functions. The body with its activities, in these other cases, is looked at from without. Its form and functions correspond in general with the observer's own. Concerning the question at issue regarding this physical organism the only ground for inference is immediate experience. Within that field falls one case in which such a system of activities is known to be more than physical change, namely, in the case of the observer's own body. This, however, is not one among a number which do not conform to its type; it is not an isolated case in a larger field, an exception to the rule. On the contrary, it is the sole case known to him, and the situation may be stated thus: Wherever consciousness is known to exist it is in correlation with a physical body and its changes. The one instance exhausts the universe of experience. If, then, in the only case in which the problem of physical and mental correlation is actually resolvable, the connection be found to exist it is logically to be predicated in all those other cases in which one of the two correlated factors is given. An appreciative inner life is therefore asserted in connection with the activities of all human bodies alike.

The system of physical activities which constitutes the basis

of inference in the case of other persons cannot of course be observed with any approach to the intimacy with which it is known in the case on our own bodies. Little of that complex manifold of outer and inner changes of which we are immediately aware is apparent to another observer. One cannot hope, then, by the inspection of such aspects as are discernible in another body to arrive at an adequate acquaintance with the correlated mental attitudes. Nevertheless the likeness is sufficient to warrant us in the general ascription of a mind which duplicates the main features of our own while departing from its type in a variety of particulars.

There is perhaps no one element of these bodily changes which we can call essential to the correlation in question,—such a physical activity that its absence would entail a denial of the mental correlate in the given case. To differ from our own body in specific points, we say, is not to lack a mind in its entirety but to possess a mind differing from our own in individual features. We make provision for a series of divergent types within the realm of minds.

Since the basis of interpretation in all cases is a system of physical changes, and the associated type of mind is conceived to be reflected in its characteristic forms, the mental system will vary correlatively with alterations in bodily structure and function. Now, in the case of the physical correlate there is presented a series of progressively diverging types which, without essential break, carries us forward to forms extremely unlike our own,—organisms in which every individual feature is altered, which present none of those special structures or activities upon which the interpretation of mental constitution in our fellow-men depends. Indeed the series may be carried continuously through the succession of organic types until we have lost all but the most general properties of living substance and are confronted,—for example in the world of plants—with forms and relations which afford almost no practicable ground of comparison with our own.

If the imputation of mental life, in either its specific or its generic characters, be dependent upon specialized activities or connected with forms of structure, that life manifestly cannot be attributed throughout this whole series of forms. We must formulate the special criteria upon which our attribution turns and seek to define the limits within which alone we apply this mode of interpretation. In considering the distribution of mind, however, there are two questions to be taken into account: the first touches our criterion of the possession of mental life at large; the second affects the evidence for the

existence of a conscious aspect in the case of any individual physical activity.

II

The problem of the extent of correlation between physical and mental changes is not met for the first time when the limits of human activity have been passed, nor even when the interpretation of expressive reactions on the part of other men is undertaken. The observer is confronted by it within the field of his own immediate activity, in the problem whether all bodily processes are accompanied by consciousness, and *per contra,* whether all these processes are subject to modification by consciousness. The latter question need not here be considered. The remaining problem presents three possibilities:—first, that the whole system of physiological changes is reflected in consciousness; second, that there are certain activities which as a class are always unconscious and others which likewise are characteristically accompanied by consciousness; and finally, that any individual process may now have a form of consciousness correlated with it and then lack such an accompaniment, according to the conditions under which it occurs.

The classical answer to this problem is that only one form of bodily activity is immediately connected with mind, namely that of the central nervous system; and that any other physical or physiological process must be mediated by nervous activity if it is to be represented in consciousness. But as the central nervous system is both geographically limited and protected against direct exposure to stimulation arising in the external world it does not, without supplementation, provide the basis for a representation either of the external world or of the organic changes occurring in the body at large; nor is it fitted to be a medium for the expression of mind either in terms of characteristic changes within the body which parallel the mental attitude, or of transformations wrought in the external world through its agency.

On the other hand, the nervous system is made co-extensive with the body by an intricate system of outgrowths which penetrate every part of the organism; and it is brought into relation with the external world through the system of end-organs attached to it. In its constitution also the nervous system represents the two relations in which the connections of mind and body are characteristically read: it comprises a sensory aspect which makes possible the representation of the series of special stimulations acting upon the end-organs

of sense in terms of central nervous change; and it comprises a motor aspect which makes possible the expression of the series of central changes in terms of muscular contraction. In this sense the central nervous mass has been called a projection system for the whole series of sensitive and mobile points comprised within the limits of the organism.

The nervous system thus stands in unique relations with the body as a whole. It has no such specific function as have stomach, lungs, heart and kidneys. It contributes no new physical characteristic to the body. It does not even form the necessary condition of discrimination and adaptive response. Its function is to be called general rather than specific. It co-ordinates and integrates the whole system of bodily activities; no organ or living tissue but is penetrated by its fibrils, no function or reaction which proceeds in independence of it. Touching every part of the organic system and reflecting both its sensitive and reactive aspects the nervous system is thus aptly constituted to function as the physical basis of consciousness, if we view the latter in terms of its correlation with the whole sysem of activities which the body manifests.

In order that consciousness shall be predicated under this conception there must finally be an activity within the nervous system, and such activity will be accompanied by a characteristic consciousness whatever its original cause. No other physical process, on the other hand, will ever be accompanied by consciousness unless it finally gives rise to some form of central nervous change. But as every part and function of the body is connected with the nervous system the necessary conditions are given for the reflection in consciousness of the state of activity in the body at large and of each specific change occurring within it. We cannot restrict the system of modifications thus represented to limits narrower than the total group of functions with whose structural basis the elements of the nervous system are interwoven, and must therefore say: the activities of the body as a whole are representable in consciousness, in the sense that a change occurring in any part of the body may produce a definite effect upon the consciousness of the moment.

On the other hand, if the possibility of an arrest of functional activity within the central nervous system be admitted, or an interruption of continuity between that system and the rest of the body, there will be no necessary representation in consciousness of any process occurring without its own immediate bounds. Whether, in that case, any individual change is to be represented in consciousness or not will depend upon

the functional integrity of its locus with the central nervous system at the moment. As conditions change it will now be represented and then not.

The whole systematic correspondence between mind and body will thus be thrown into doubt, since their relation depends upon the permeability of lines of connection between the central nervous system and the rest of the body. If these lines be closed, neither will the peripheral change affect the central nor will the central modify the peripheral,—neither will stimulation be reproduced in consciousness nor will mental attitudes find expression through muscular change.

In the interpretation of physical processes in terms of mind a question of validity is thus raised at the outset; it cannot be deferred until outlying types of organic life are reached. Even in our own bodies the situation is obscure, and it has only been at the close of a long and slow historical development that technical students have themselves adopted as their working hypothesis the concept of uniform correlation between mental and physical changes even in the relation of the central nervous system to the mind. In every case it is indeed rather the logic of the situation than specific evidence which determines our judgment in these matters. It is impossible to indicate the minute ramifications of that process of bodily change in which our mental attitudes find expression, and it is equally impossible to trace in consciousness the reflection of each element of that vast and subtle system of modifications occurring in the body as the result of physiological conditions and physical stimuli.

The fact that any individual change in the body may or may not be represented in the consciousness of the moment, according to circumstances, enormously complicates the situation by which the psychologist is confronted when he inquires concerning the distribution of mind; and out of it arises a series of special problems. The general question of representation in consciousness may be raised concerning any bodily activity whatsoever since modifications in the central nervous system are hidden from psychological observation, the data upon which interpretation proceeds being invariably peripheral in character. Nor is the range of ambiguity limited to the series of sense-impressions in their relation to central nervous activity. By a further complication the products of motor nervous activity themselves are subjected to doubt. These processes, which by assumption are the direct result of central nervous activity and are habitually accepted as the characteristic expression of mental attitudes, do not necessarily

occur in isolation from the activity of the central nervous system when their significance is thus questioned. Within that system itself a division between higher and lower is found necessary, the higher levels of nervous change alone,—those namely which depend upon the cerebral cortex itself—being conceived as the essential correlate of mental activity. If the motor reaction does not involve these higher centers it will then have no representation in consciousness.

The division of peripheral activities to which this conception gives rise does not present two separate groups depending upon different muscular tissues, the striped and unstriped for example. It is the same movement which is now conceived to involve cortical activity and then to proceed in independence of it. In this fact lies the peculiar difficulty of interpreting reactions in terms of their mental correlates. The physical datum bears all the characteristic marks of a consciously determined act. It is an adaptive response to the situation and objectively expresses intelligence and purpose. It may both present a high degree of complexity in itself and represent an external situation which is similarly complicated. Its form may be such as could result only from a long-continued process of training originally dependent upon high intelligence. To conceive such a reaction as occurring independently of consciousness at any stage of its history may thus be a matter of difficulty, and its proper interpretation is rendered still more complicated by this persistent tendency on the part of the observer.

The psychological significance of any act, as well as of any impression on a sense-organ, will thus depend upon its relation to the central nervous system, not in the sense of its general structural or functional connections but of the situation which exists at the moment between the peripheral process in question and functional activity in the highest parts of that system.

The evidence upon which judgment turns in such cases will be sought either in a determination of the relations in which the two processes stand, according to physiological or histological methods, or it will take the form of an objective interpretation depending upon the whole logical situation presented. The first of these alternatives is completely impracticable as an experimental means of settling the individual case, and its inferential application is excluded by our lack of knowledge concerning the actual neural conditions under which such continuity is or is not to be expected.

Thus in a series of special activities lying within the field

of normal adult experience the question of psychophysical correlation is already raised. Which process is reflected in consciousness, which is dependent upon consciousness, cannot be told on the basis of specific character in the physical activity involved. Both stimulus and reaction share in this ambiguous character. The impression on eye or ear may have no representation in consciousness if functional integrity with the central nervous mechanism be at the moment interrupted. Such breaks appear to be caused incessantly by the distribution of attention. Familiar impressions,—continuous or repeated sounds, contact with clothing, odors in the room in which one is at work—thus fail of representation. In sleep the connection is so far broken that the general system of sensory impressions is shut off from the cerebrum. Yet we know that these stimuli from the outer world may occasion changes in the dream content and thus be reflected in the sleeper's consciousness.

The question whether such connection may not be more widespread than is supposed throws this whole series of relations into doubt. The distribution of dream-consciousness is itself a case in point. That much of our sleep is pervaded by a mental concomitant none doubts, for the first moments of waking consciousness frequently retain images which have been carried over from dreams and the connection is thus established through memory. But the extent of this correlation and the connection in general which obtains between the physical changes occurring during sleep and activities of consciousness have as yet received only a speculative formulation.

III

Within this group of cases falls a large number of more or less exceptional forms of activity, as well as several types which are essentially normal and important. The exceptional cases are those which, in general, have been described as due to conditions of ' disaggregation ' in the nervous system. They commonly occur only in connection with a definite and highly integrated form of consciousness. They involve complex conditions of reaction and complicated types of response. Frequently their forms are the result of secondary modifications of behavior and represent conventional modes of reaction. They therefore stand for consciousness in the most direct way and we call them, in the narrowest sense of the term, expressions of mental attitude. The occurrence of such responses as the use of the tongue in speech or the hand in writing, for example, is difficult to conceive apart from a mental

content of which the product is a specific expression. Yet the condition under which on some occasions these reactions occur raises the problem whether in fact the complex movement had such a conscious correlate or not. In the handling of objects with which the fingers accidentally come into contact while the mind is otherwise engaged, in automatic writing and mimetic movements, in the speech of one who answers in his sleep to a call or question, in the reading which one continues in the face of overpowering fatigue or drowsiness without, for a time, any awareness of meaning or movements, in the speech of hysterical subjects when a so-called secondary self has been evoked,—in all these cases certain similarities of condition exist and a common problem is raised.

These acts are the characteristic expression of our most highly developed forms of consciousness; but in all the cases in question special features exist which we interpret as marking its absence. The subject is in general unaffected by the changes occurring in the world about him, as in sleep; or he has no intention to perform the movement which takes the form of a voluntary act,. nor remembrance of it after it has taken place, as in mechanical responses; or his whole significant consciousness seems otherwise engaged at the moment, as in automatic writing and the speech of secondary selves.

The problem of interpretation therefore arises in a special way in connection with all such cases. Shall we conceive the form of response so elaborated that by some provision within the nervous system the impression is drafted off into an adaptive reaction in a way which does not involve the central cortex at all, and that in consequence it is not conditioned or accompanied by consciousness? Or shall we say that a consciousness of both the condition of reaction and the form of response was there but never as the object of engrossing attention and irrecoverable in after-consciousness? Or shall we say, finally, that consciousness is not to be conceived as a unity, being the correlative of certain systematic activities within the nervous mass which do not necessarily involve the system as a whole but may constitute functionally independent and co-existing processes of response; and that a dissociation or disaggregation within the consciousness of the self is possible; two, or a series of such supplementary or split-off consciousnesses thus potentially co-existing in correlation with a single organism? It is a question of interpretation which cannot be answered by an inspection of the type of reaction but must turn upon a consideration of the whole situation involved.

If we accept the first hypothesis, that in such cases the reaction is mechanized in the sense that it is unaccompanied by mental activity in any form, it seems to throw doubt upon the whole process of inferring consciousness from behavior. If we make the second supposition, the function of introspection is invalidated as a criterion in the determination of the problem. If we assert the final alternative it undermines the unity of consciousness and makes the self of psychology a dissolving aggregation of individuals. For in the latter case there is no inherent principle of limitation in the number of socalled selves to be predicated. Any systematic form of response which has attained relative permanence in the complex of functions is sufficient to afford the basis of such a separate self. Thus in every automatic process of the body would theoretically be grounded a consciousness, narrow indeed in its content, but highly integrated and enduring. Under this hypothesis, for example, there would be spinal as well as cervical selves, and within the former field lumbar as well as cervical; for if we are to conceive disaggregation generally spinal consciousness is but a term for the series of complex mental correlates representing the various levels within that system. Man thus becomes a microcosm and represents in himself not only primitive and highly developed forms of reaction but also the correlative series of mental types from protozoan to man.

Thus we need not go beyond the phenomena which normal human experience presents in order to be confronted by the problem of the distribution of mind. It appears in every consideration of bodily activity and presents aspects as perplexing as can be found anywhere within the psychologist's field. Nevertheless it is in connection with mental types rather than mental activities that the question has chiefly been raised. With this form of the problem we have already come into contact. The phenomena of sleep and their relation to the problem of consciousness are matters, it may be said, of the type rather than of any individual bodily activity and its correlations. One may arrange a series of gradations from complete waking life with its vivid and complex mental content to profound slumber with its supposed absence of all consciousness. As one grows drowsy and passes into sleep, mental activity becomes less complicated and its content simpler. The mind slackens in alertness and its self-control is weakened. The mental content becomes disaggregated and breaks of increasing significance appear within its associative

processes. The senses are dulled, impressions grow faint and one by one disappear. Finally the sense of self is lost and consciousness vanishes in a dim awareness from which even the last discrimination of subjective and objective has disappeared.

This succession of changes points to a theoretical limit in which consciousness completely vanishes and a purely physical system of changes is presented. Not only in the natural unconsciousness of sleep but also in states artificially aroused or due to abnormal conditions, such as fainting and coma, anæsthesia from drugs and insensibility due to shock or blows, there would then be predicated a field within which no mental correlate attends the physical series of activities which continues to exist.

In these cases, of course, the condition is either exceptional or due to temporary functional relations; but in its more pronounced departures from our own the condition constitutes a characteristic type and reflects profound differences in structural organization. The beginning of this series of types is presented within the human species in two forms. The first is exceptional and consists in abnormal underdevelopment of the organism. In low-class idiots, and, in extreme degree, in anencephalous monsters the general question of the connection of physical activities with consciousness is unavoidably raised. No idiot type, perhaps, justifies a thoroughgoing application of the concept of mechanism, a reaction to stimuli unilluminated by consciousness; but the general want of intelligence, the lack of capacity to receive training, the absence of alertness, the simplicity and fixity of reactions, the rhythmical form which activity presents, not only provoke reflection in regard to the significance of any individual response as an index of consciousness, but mark the idiot as an important intermediate type between full human intelligence and a form of existence in which, from its anatomical incompleteness, consciousness must be absent if the existence of a cerebrum is to be taken as its structural basis.

In human anencephalics the organism is sensitive to a variety of sensory stimuli to which it makes adaptive responses. Food is taken and assimilated. The functions of the great organs are performed and the individual is in every way living and adaptive. But consciousness cannot be predicated even though the organism belongs to that type with which it is most typically connected; for there is an absence of that very

structural basis with which, in advancing measure, intelligence is connected throughout the whole animal series.

The second typical departure from the conditions of a complex and integrated consciousness which falls within the human limits is to be found in the earliest developmental stages of the normal individual. The mental content and its forms of integration grow more meagre as we retrace the history of the individual through childhood and infancy to the hour of birth. There the chief part of the objective system of stimuli to conscious activity disappears, so that what content exists during the later uterine period, when the formation of organs has been completed, is incomparably simpler and more vague than after birth. Retracing the process still farther the organic types which the growing organism represents become simpler and more primitive until with the disappearance of the nervous system and the reduction of the organism itself to a mass of undifferentiated cells there is dissolved the whole structural basis upon which the specific attribution of consciousness is made. Either, then, the descriptive content of the term must be given up altogether, or it must be recognized that in the course of these successive transitions there has disappeared that very phenomenon with which psychology is concerned.

Both of these series of types, that which runs through idiocy to the anencephalic condition and that which runs through infancy to the fertilized ovum, lie within the limits of the human species. The third series is that presented by the taxonomic system of living forms. This system, like the former, is characterized by a succession of increasing divergences from the human type as the scale is traversed in regard to both structure and behavior. Concerning those animal types which most closely resemble our own in anatomical features and modes of reaction our judgment is commonly unhesitating. To these, as to other men, a mental life is attributed, and interest centers only in the problem of its specific features and their relation to our own. But as the series is followed farther and the sum of differences increases on the structural as well as the functional side our interpretation hesitates. The system of changes is similar to that which appears as the ontogenetic series is retraced; and the final types with which we are confronted are identical in the two cases, that is, they are single-celled organisms which perform all the essential functions of life but without differentiated structures and in ways that must raise the question

whether there is any further value in the inference of an accompanying consciousness,—an inference which is inevitable in the case of the higher species and our fellow men.

In all these series,—taxonomic and phylogenetic, ontogenetic and functional, gradual differentiation and simplification appears, leading at last to radical unlikeness of type. In each case, therefore, the problem of definition and limitation arises and in each case it can receive only a speculative answer. In the attempt to apply this principle of discrimination one must be guided by the whole system of phenomena when no single outstanding feature can be pointed to as the specific correlate of consciousness.

The answer to this problem has been given in terms of four different concepts. The first is that of concomitance between the elementary constituents of mind and matter; the second that of the concomitance of mind with specific grades of material organization; the third that of the concomitance of mind with particular types of adaptation; and the fourth that of the concomitance of mind with certain phases of functioning.

IV

According to the first conception psycho-physical correlation is universal. Mind and matter alike are atomic. As the things of sensible experience are made up of parts and elements, so are individual minds the products of a synthesis of simpler functions and ultimately represent atomic combinations of a primitive mind-stuff. The elements of reality are arranged in pairs, or if the unit of existence be conceived monistically, each monad is at once physical and mental. Every material atom has its own atomic consciousness, each particle of mind-stuff its own body and expression. Under this conception reality is essentially dual. The universal existence of mind as the correlate of matter is posited; consciousness is diffused everywhere in reality. Its existence is a general postulate, not a particular and contingent fact whose distribution is to be determined.

One aspect of the problem is thus eliminated. The inquirer is not called upon to indicate the point at which consciousness appears in the series of organic types nor to assign limits to its occurrence, for it has none. It accompanies all physical existence and change. The essential characteristics of mind must be granted to the simplest forms of existence. Not only will all life be thus marked, but the objects of the inanimate world and its elementary particles as well must be conceived

as subjects of feeling and desire, as manifesting individual will.

Though the particular application of this conception in the interpretation of mental content presents evident difficulties, its methodical service is clear. It provides a doctrine of continuity in the interpretation of behavior. It urges the importance at every point of conceiving the simpler forms of life or of action in consistency with the more complex. It affords a way of stating the process of mental evolution by the complication of elementary activities in higher and higher processes; and conversely of treating the functions with which at any stage the psychologist has concretely to deal by resolving them into their theoretical constituents. It provides a metaphysical basis for the assumption of a psychological atomism both in immediate psychical analysis and in the interpretation of ontogenetic and phylogenetic development.

The second conception limits the distribution of psychical phenomena by assuming a specific grade of physical organization as its basis. The criterion of consciousness commonly adopted in this case is the presence of a brain in the organic system. Beneath this level as well as above it extend life and its phenomena; but in the former field its activities are conceived to occur in independence of any conscious correlate. Digestion and assimilation are there, growth and reproduction, even discriminative selection and appropriative reaction, but no consciousness. The adaptations are physiological not psychical; they are tropisms determined by physical irritation and involving only chemical syntheses and disintegrations. But above the line thus drawn the processes in question are conceived to be accompanied by consciousness. Reactions do not simply occur, they are elements in a mental life. The stimuli not only produce responses as before, but they are also sensed as they arise and, in some forms at least, are remembered after they have ceased to act.

The assumption of such a criterion definitely limits the field of consciousness and consequently marks out the bounds within which psychological inquiry may be made if the purpose of that science be, as is commonly stated, to give an account of the phenomena of consciousness and not to describe the behaviour of the various types of organisms. In tracing the outlines of that field of inquiry within which immediate introspection does not suffice, as is the case with young children, persons of diseased minds and the lower animals, the psychologist is thus guided by a specific test, namely, the

presence or absence of an encephalon. Where the organic life is conditioned by a brain its phenomena afford subject matter for psychological treatment; where the brain, or the nervous system as a whole, is lacking no interpretation in terms of subjective reality is to be made.

This conception is doubtlessly fostered by our sense of the enormous difference which separates our own conscious life from the behavior of plants and invertebrate animals. The difficulties by which we are beset when we endeavor to treat the phenomena of adaptation in these lower ranges of life in terms derived from the manifold and highly definite activities of our own conscious existence are practically insuperable. In its specific content consciousness is limited to a special field within the region of life as a whole, and the term is emptied of significance when we try to make the two co-extensive.

The division does not fall at the boundary which separates animal from vegetable. Within the former class occur forms of life which, in common sense, must be affiliated with the plant and its reactions rather than with our own conscious life. The protozoa as a group belong here, as do also the colonial metazoa, the coelenterates, the molluscs and perhaps even the worms. The differences which separate these types from the human are of course not completely represented in the absence of a brain; they penetrate the whole body and include sensory mechanisms, muscular tissues and general anatomical scheme. But if we are to single out one special feature to be employed as a criterion no other offers so available a test as the presence or absence of a brain. It is a profound characteristic the existence of which carries many implications. It marks a certain grade of development at large with relative precision. Its existence is characterized by specific forms of behavior which are absent in types lacking such an anatomical feature.

The use of the brain as a criterion of consciousness is a measure in defence of meaning. To make consciousness co-extensive with physical existence is to strip the term of all that determinate content which gives it significance when applied to our own life. To retain meaning the term must be limited in its scope, and to restrict its application to organic forms characterized by the presence of an encephalon is to select that physical structure which we find most intimately conditioning our own mental life as the test by which the presence of a life essentially similar to our own is to be determined.

On the other hand there are obvious difficulties to be encountered in the application of such a criterion. As regards behavior the world of life is not divided into two distinct groups marked by specifically different reactions, the cephalic and the non-cephalic. The development of behavior presents no evident breaks. Higher and lower groups are connected by a series of intermediate types which present relative continuity in their relations. Instead of being far withdrawn from each other, the one group passes into the other by insensible gradations. If there be grounds, as regards external organization, for the limitation of the field of consciousness, it cannot be said to have its justification in any sharp delimitation of two classes of animal behavior associated with the two organic types respectively.

Further, if regarding behavior as the objective manifestation of organization we turn to the question of structure the same lack of demarcation will be found there also. The world of life is not divided into two isolated and contrasted groups, one possessing a brain and the other lacking it. The cephalic type presents a range of variations marked by very great differences in complexity and integrity of organization between its highest and lowest members. The non-cephalic group, likewise, includes such extremes as the complete absence of nervous elements in the protozoa and the high development of the segmented type in the vermes. Moreover, the two groups are in immediate contact at their edges. No anatomical chasm separates the two, such as divides, for example, any two species separated by intermediate types. When followed downward the cephalic type is found to disappear in forms difficult to classify. Indications of a brain appear in the swelling of the foremost nerve-bulbs, but so slightly do these changes alter the essential type found in the upper grades of the group below that classification may even be said to turn upon the relations in which the type in question is conceived. One who is tracing the development of the segmented type of nervous system will see in it a non-cephalic structure; one who is following the development of the brain will find in it the progenitor of all higher cephalic forms. It is an intermediate type.

The rise of the evolutionistic point of view has given a new meaning to all such intermediate forms. These types do not, as for earlier systematists, simply obscure the problem of classification; they mark a genetic, not merely a logical, relationship among the types which they connect. Even when

breaks are found, therefore, continuity must still be assumed. The cephalic type has arisen by successive modifications from the non-cephalic, and the higher of the non-cephalic from the lower in unbroken succession. A fundamental protoplasmic continuity thus unites the highest cephalic forms with the lowest and wholly non-nervous types of organic life.

The psychological difficulty which attaches to such a division of the world of life into conscious and non-conscious groups appears in its full bearings only when one turns to the phenomena of embryonic development. Whatever may be said as to the magnitude of the differences which separate proximate forms in the evolutionary series and the significance of the mutation theory, the young of any member of the higher or cephalic group at least passes by a continuous process from the non-cephalic to the cephalic type. The earlier form of organization is not replaced by a later and disparate structure but is itself transformed into it by insensible modifications in the course of a continuous life. Here, therefore, the division becomes merely a convention which is useful in marking stages of organic development separated by differences of a certain magnitude but implies no interruption of continuity such as the distinction at first sight seems to imply.

Within this second category apparently fall various attempts to express psychical activity in terms of relational concepts derived from the physical sciences. The material phenomenon in which attention centers here is that of change or energy. One may conceive the relation as universal and interpret all physical activity in subjective terms and say that every manifestation of force is the expression of purpose and will. The distribution of mind is thus made co-extensive with that of matter, since all material existence is manifested through resistance. The distinction which is made between motion and resistance must then be within the general field of subjective experience; it cannot be a delimiting concept which makes will correlative with motion, leaving resistance outside the field of subjective phenomena. The two forms of force can only be differentiated in some such terms as offence and defence, as aggressive and self-preservative aspects of the universal psychical.

In this form the theory differs from that first described only by the modification which appears in the fundamental concept of the physical world. If mind be the correlative of all physical change,—the subjective aspect of energy—then

all material existence possesses such an aspect. No complex of substances lacks it, since all compounds must be described in terms of a system of forces; and no atom of matter can exist in separation from it, unless we say that in so far as the atom is not impinged upon its resistance is only a potentiality, the concept receiving a positive content through the conflict with other atoms. We should thus have to speak of the sleep of the atom and its awakening through the occurrence of stimulation. If the atom be defined as an hypostasis of energy and nothing more, as simply the metaphysical bearer of motion, then no such distinction would be in place. The system of subjective experience would be a thoroughgoing correlate of the system of energy which the physical world represents.

Within this general field various modifications of the concept in question appear. In one of these consciousness is conceived as a special form of energy, one of many, each of which has its own specific characteristics. Light is such a special form of energy and heat, electrical activity and chemical affinity. Among these appears consciousness, qualitatively unique as is each one, but of the same order as the rest. Under this conception the distribution of consciousness is limited and particularized. Energy as such does not manifest it, but energy only as it appears under special conditions and relations. One mode of motion is manifested as light, another as heat, a third as consciousness, a fourth as electricity, and so on. The appearance of consciousness is thus conditioned by the existence of certain specific forms of physical activity.

But all differences in physical processes are associated with determinate variations in structure. This conception may therefore be said to constitute a modification of that which bases the determination of consciousness upon the existence of a certain type of material organization.

In still another form of this concept consciousness is made the subjective aspect of latent energy. Under certain conditions motion disappears and is dissipated, as when a spring is released or a stone drops to the earth. In other cases motion disappears but is not dissipated. It remains available for future use and may be retransformed into kinetic energy, as when a spring is compressed or a stone reaches the highest point of its ascent when thrown upward. The capacity of a compressed spring or a lifted weight to do work is called latent energy. This condition of latency in physical energy,

according to this form of the criterion, is what we know as consciousness. Wherever latent energy appears, therefore, consciousness must be posited. It is thus made a characteristic not of nervous matter or living substance but of all grades of material organization and may appear equally in a stone and in a man,—equally, that is, in respect of its formal existence, not of its specific content. For as one condition of stress must be treated as complex and another as simple, so also must consciousness, or latent energy, present analogous modifications in composition.

V

The third criterion looks primarily to reaction but involves a reference to anatomical bases as well. Consciousness is here conceived as the concomitant of general or specific modes of response to the environment. The general forms of behavior, as well as the specific types of reaction, which characterize the different organic forms vary within very wide limits. The specific reaction-types depend for their form upon the nature of the stimuli to which the organism responds and the systemic features which condition reaction. Sense-organs and muscles provide the material basis upon which the forms of animal behavior are founded, and variations within these systems of mechanisms make very great, and in certain ways characteristic, differences in the organic type.

But to complete the description of behavior a second group of facts must be included, for behavior is a question of the uses to which the materials afforded by sensations and muscle complexes are put. The range of movements may be wide or narrow; the forms of response to a given stimulus may be highly defined or diffuse and obscure. The reaction which is called forth may be fixed or variable, simple or complex, confined to a single form of muscular adaptation or resulting in any one of the whole series which the structural plan makes possible. These differences in the general character of the response which the organism is capable of making mark the distinction between high and low grades in the scale of behavior. That reaction is superior which is highly defined, complex and variable,—in other words, which shows modification in response to characteristic differences appearing among the system of stimuli. That organism is high in the general scale of behavior which is marked by the capacity for a wide range of stimuli discriminations and of differing muscular reactions on the one hand, while on the

other its responses present refined modifications corresponding to variations in the specific conditions of reaction.

These features of the organism's adaptive response are of value not merely as means by which behavior may be characterized, but also because they may be used as a criterion of the distribution of consciousness as a concomitant of specific forms of behavior. Introspection reveals certain evident connections between these two things. Our simple, highly defined and relatively fixed reactions are accompanied by a form of consciousness which is at least commonly obscure, if consciousness can be asserted at all as their uniform concomitant. It is those experiences in which the response is complex, diffused or subject to great variation which are typically and intensely conscious. Most of all is consciousness characteristic of situations in which a definite response has not yet been established, or is not at the moment discoverable. With the progressive clarification of the situation,—that is, with the full discrimination of the system of stimuli involved—and the establishment of a more and more direct and fixed connection between the situation and its interpretation,—that is, with advance in the direction of setting up an immediate adaptive response to the stimulus—consciousness declines. In the most highly defined forms of reaction, even when such development represents an acquired modification, consciousness has ceased to be a discernible accompaniment. The type of such highly automatized responses is to be sought in the most simple and fixed forms of reaction, whether acquired or congenital, voluntary or involuntary, modifiable or unmodifiable.

If we take this series of facts as our guide we shall find ourselves recasting the conditions of consciousness in terms of the complications which appear in the form of animal behavior. A certain grade of complexity, or a certain degree of variability, in the response will now become the criterion of its presence. A variety of modifications in this concept is possible. The criterion may turn upon the inner wealth of discriminable stimuli and the complexity of the elements of possible response. The form of human consciousness is closely related to the rich manifold of stimulations to which the human body is susceptible, and to the variety of motor reactions which its structure makes possible. Where, then, the organism presents a certain range of stimulations and variety of elementary reactions we may say: here is the necessary background against which consciousness is to be pro-

jected, from the existence of which its presence is to be construed.

With the same general situation in mind, namely the inner richness of the elements of stimulation and reaction, attention may, in the next place, turn to the nature of the connections which exist between the specific classes of stimuli and the particular reactions which they prompt. In one case these connections may be in a single direction,—as when a local reflex occurs or a peristaltic movement takes place—in which case the association between stimulus and reaction will be highly definite and fixed. In another case the connection may be a multiple one, each specific stimulus being capable of calling forth not a single limited reaction but any one of the whole series, made possible by the structure of the organism. In such a case the stimulus has no fixed line of discharge. The field of its potential effect is the whole system of activities which the organism represents. It may characteristically result in a single and direct discharge, in which case it will be least conscious. (If the discharge be exclusively into the one reaction system it will theoretically be unconscious.) It may result in a discharge accompanied by diffusion of excitement over a larger area, in which case there will be a reaction accompanied by consciousness,—a reaction apprehended or intended. It may result, finally, in a general diffusion without specific reaction, the whole group of associated reaction-systems taking up the shock of the stimulus and absorbing it without localized response. What this situation presents is not, strictly speaking, the absence of all tendency to reaction but the summation of all such tendencies, which at the instant are so related that their combination produces a state of suspension,—in other words, the content in such a case is to read positively not negatively.

It is these cases which are typically suffused with consciousness. They constitute the experience of hesitation, doubt, deliberation in so far as their relation to adaptive response is concerned, and that of supplementive association, of apperception or interpretation of the situation in so far as relates to the stimulus.

This conception, it is clear, involves a reference to the structural complexity of the nervous system and cannot be isolated from the grade of organization which is thus assumed. But every criterion based upon reaction type involves the same reference, while it is, of course, true that the phenoma to which attention is directed in all these cases is

not the system of anatomical features as such but the type of behavior which it manifests. In this form of test the central element is the variability of the reaction to stimuli.

This appeal is seen in another and perhaps more complex form of behavior criterion, namely in the insistence upon progressive modification of reaction in response to changes in the system of stimuli. It is more complex because it turns to a further aspect of variability as the criterion of consciousness. The whole inner richness of stimulation and elementary reaction may be assumed and the internal diffusion of the stimulus over a wide system of elements together with the conditions of its transformation into any one of a multitude of different responses may be given, yet one may still conceive the absence of a conscious correlate. The number of the elements and the complexity of their relations are not sufficient, if variability be made the controlling idea in our conception. For even in a complex organization, such as is here imagined, equilibrium may exist in the sense that the system is capable of attaining a condition of stability in its relations. In such a case the stimulus must be conceived as taking a definite and habitual, though highly complex, course of irradiation, a given stimulus-type producing on each occasion the same wave of redistribution within the group of elements. The system of things will be complex but not necessarily varied. The organism may therefore be regarded under the conception of automatism and its reactions described in terms of purely physiological tropisms.

VI

In the face of this theoretical possibility a further phase of variability is seized upon: consciousness shall be predicated only in those cases where the whole system is subject to modification in response to progressive changes in the stimuli which act upon the organism. In other words, the capacity to learn from experience will be made the criterion of consciousness. If the learning process itself be the point to which the mind turns in this analysis the criterion will be called the modifiability of behavior; if it be the influence of experience in such modification it will be termed organic memory or the like.

The advantage of this last group of conceptions is evident. In their application the field of discussion shifts from theoretical to practical considerations, so to speak; the evidence is no longer secondary and derivative but primary and imme-

diate. That is to say, the criteria now appealed to are no longer abstract or technical, but just such as we use in our general human interpretations. The universal basis on which consciousness is popularly predicated is that of conduct or behavior, not of organization or anatomical type which, though confessedly the substrate of behavior-modes, is largely removed from direct observation and revealed only through the slow progress of descriptive science.

The starting-point of all such attribution of consciousness in connection with other organisms is our intuition of the expression of mental states by characteristic reactions in our own experience. Upon the felt identity in behavior proceeds our inference of likeness in the psychical correlate; and, far as this inference may be pushed, it is still in practical judgment dependent upon the observation or assumption of a conduct basis.

In the conception now described this characteristic is made the systematic criterion of the distribution of consciousness in the organic world. If the behavior of the type in question is essentially like our own, or at least like those simplest forms of reaction with which in our own immediate experience we know consciousness to be associated, we conceive the life of such an organic type to be characterized by a conscious correlate. The difficulty in applying this criterion lies in the function of interpretation. The complexity or variability of behavior is really an inner complication of the situation, not an immediate and obvious feature of the reaction objectively considered. A simple muscle contraction, from the point of view which must be taken here, may be a most complex act. Delay in the response to a stimulus,—the very failure to appear itself,—must often be construed positively as a real and highly developed reaction. Every response must thus be given its full and proper setting in the dramatic reconstruction of the situation under analysis; and in this synthetic representation the observer may err either by ascribing to behavior a complexity which it does not really involve or by reducing it to terms of too great simplicity. Comparative psychology has wavered between thinking the brutes human and making them automata. The popular conception of animal life undoubtedly errs by reading into its reactions a complexity which the evidence does not justify; while recent psychology has, in some cases, adopted a schematism which reduces higher forms of behavior to chains of simple and unmodifiable tropisms.

The question at issue, however, is not as to the identity in

structural formula of tropism, instinctive response and purposeful action, but of the presence or absence of variation in the inner complexity of the organism as the subject of reactions. It seems on the whole likely that we shall have to modify our conception of the simplicity of behavior in even the most elementary organisms and ascribe to them a selection and initiative, a variety and complexity of reaction for which the theory of tropisms does not make sufficient room.

The final conception, which should not perhaps be given a separate place, makes consciousness neither the necessary correlate of a certain grade of organization nor yet the uniform accompaniment of reactions of a certain complexity. It maintains, on the contrary, that there is no necessary correlation between the type of structure or function and consciousness, that the latter appears and vanishes in connection with even the highest forms of behavior. It is an evanescent phenomenon which hovers over the physiological process only during certain phases of adaptation, namely those stages in which the response is uncertain and hesitation arises as to the reaction to be made. Consciousness thus appears as the mark of imperfect adaptation. In those organic forms which are characterized by few and simple relations with the environment adaptation may reach a high degree of determinateness, and consciousness will then scarcely rise above the vanishing point. As the multiplicity of relations increases and the complexity of the conditions which each reaction represents grows greater the field of consciousness will develop. The range of reaction alternatives which a situation presents to any individual or organic type is the measure of uncertainty in its responses. When life is constituted of a succession of situations every element of which presents inner complexity, then novelty, doubt, choice, striving and reconstruction will never be absent. Consciousness under these conditions will therefore be continuous and pervasive, variations arising from the swing of its focus from point to point in the system of correlated stimuli and reactions.

While consciousness may be called self-eliminative in the sense that it is the characteristic accompaniment of those processes in which an adaptive reaction is in course of establishment through progressive selection,—the result of which is decline and eventual elimination,—its disappearance from the system of changes never actually results, since new points of friction constantly appear, thereby providing the basis of a continuous mental activity. The sources of these novel occurrences must be stated in terms of two systems of factors. The

first of these is the persistent appearance of new elements and combinations in the stimuli upon which the organism is called to react, which,—even in the case of the most highly organized habits,—call for incessant refined modifications in the form of behavior. The second set of factors is represented in what may be called the margin of attention. Adaptive activities have their roots in the organism as well as in the environment. The former construes the environment in terms of its own needs and purposes; when, therefore, any one element has been brought within its systematic group of reactions the energy represented in its assimilation does not lapse but, in the human species at least, is turned in new directions and engaged in fresh processes of interpretation and application. The establishment of any one habit, therefore, merely provides the opportunity to turn attention to some new problem of adaptation; one form of habituation gives place to another in endless succession. Adaptation thus approaches no fixed theoretical limit; the field of its future application is extended by each advance that is made. With the progressive refinement of adaptation which marks the transition to higher and higher grades of organic complexity consciousness therefore becomes more keen, pervasive and continuous.

This concept is, however, but a further modification of variability in behavior as the criterion of consciousness. It is an insistence, sharper and in greater detail than heretofore, upon the modification of reaction in all its phases and relations as the essential feature with which consciousness is to be connected. Not to be able to learn but *to be learning* marks its presence. It presents, therefore, no formal advantages or difficulties which are not found in the preceding group.

In the application of any such criterion a distinction in the content of the term 'consciousness' must be noted. In one sense it denotes the unity of functions which constitutes individual experience. Each psychical activity is a function in a personal life. Conceived in this way consciousness stands for an irreducible reality. Each particular process or function is but the unitary conscious life in this phase of its activity or in that, seen now in relation to one condition or object then in relation to another. Each activity must be interpreted in terms of its relation to this unity. It has no independent status and cannot be conceived except as a member in such an integrated system of significant relations.

But there is another way in which this same life may be treated. It is a complex of phenomena as well as a unity of functioning. The specific relations among the constituent

activities are subject to change; the particular constituents themselves vary. The formal scheme of their connections and sequences is therefore subject to incessant modifications. Every element and succession of this unitary mental life has a definite character and place in the system of phenomena as a whole, and the working out of their relations and laws constitutes a problem for descriptive or explanatory treatment.

It is this alternative point of view which determines the method of science. Its field of inquiry is uniformly conceived as a complex of phenomena whose correlations are to be worked out. Whether it be material changes or psychical events makes no difference. It is the nature and relations of the constituents, in the one system as in the other, with which science is concerned. Under this assumption the mental function must be isolated in thought and treated as though it were discrete. It is not memory as a phase of the self's activity with which psychology deals but memory as a system of phenomena having this relation to the facts of perception and that relation to the facts of reasoning. It is memory as depending upon this type of imagery in one individual or class of individuals and upon that in another. It is memory in its association with past impressions or future reactions; memory as it enters into imagination and conditions reflection; memory as it develops and declines in the course of individual history,—which the psychologist studies. The same holds true of course for every constituent of the mental life. The latter terms stands simply for this system of related elements, a system which presents a vast range of change both in its constituents and in their relations as the whole field within which the existence of mental phenomena is assumed passes in review.

When, therefore, we speak of the distribution of consciousness it is the complex of processes which we must have in mind, not the unity of functioning. The problem should properly be restated in terms of individual functions and their occurrence. The question is thus particularized. The psychologist does not ask what the distribution of consciousness as such may be, but how wide the occurrence of memory is, what the limits of abstract reasoning are, what organic forms share the life of imagination, at what level moral feeling arises, and the like.

For the formally single question as to the distribution of consciousness in the organic world is substituted a group of questions concerning the several individual functions and their appearance in the scale of life. Under this conception the

problem is not where a line shall be drawn separating the organic world into upper and lower halves, conscious and unconscious, but how we shall describe that world in terms of a series of complications giving a succession of levels in the synthesis of psychical elements and processes, such as Sentience, Constructive Perception, Recognition and Memory, Productive Imagination, Abstract Reasoning, and the like.

It is thus the concept of consciousness which undergoes modification as the scale of life is passed in review. The unity of functioning is assumed equally at all levels, whether the component activities be manifold or meagre. The simplest group of activities will mediate it. Were the functions reducible to a single process that unitary life would pervade it, and the greatest complication of its qualitative content or form of organization in no way modifies its essential unity.

We are not called upon under this conception to construe the qualitative modifications of this unity intuitionally. We may frankly confess our inability to conceive what it feels like to be a fish or an oyster, a sea-urchin or an amoeba. Our problem is the simpler one of evaluating evidence, at each successive level of physical organization and in connection with each complication of the reaction system, for the existence of individual constituents in the complex of mental activities at large.

ADAPTATION AND THE CHEMICAL THEORY OF SENSORY RESPONSE

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I. Hering's Theory of the Metabolism of Response

It is the purpose of the present paper to offer certain amendments to Ewald Hering's theory of the metabolism of response.[1]

This theory, which has been applied by its author principally to the visual and temperature senses, is based upon a consideration of the states of equilibrium and disequilibrium which exist under different conditions between the opposed vital processes of anabolism and katabolism. It is obvious that in a stable organ or organism these processes of constructive and destructive chemical change must approximately balance each other, and when this state of balance is determined by the forces of the living body alone it is called by Hering "autonomous equilibrium."

However, a living body is very seldom unacted upon by outside forces and if such forces cause response this must be because they influence either the constructive or the destructive phases of the metabolism. If a certain constant stimulus increases the velocity of the destructive chemical process it will tend to decrease the amount of destructible chemical substance in the body or organ upon which it is acting. In doing this it will also cause a relative diminution in the amount of such substance which can be destroyed under the influence of the stimulus in a unit of time. In other words, stimulation will diminish the sensitivity of the organ. It follows, moreover, that the rate of the destructive change will decrease constantly until—with the stimulus still acting—it is again exactly balanced by the unstimulated constructive change. This state of affairs is what Hering calls "allonomous equilibrium at low potential."

It is clear that an entirely analogous line of reasoning will follow from the conception of a stimulus whose effect is to augment the constructive rather than the destructive phase of the metabolism. The equilibrium which is finally reached

under the action of such a stimulus is called by Hering "allonomous equilibrium at high potential."

The chemical condition of an organ in allonomous equilibrium differs quantitatively from that of an organ in autonomous equilibrium. If the allonomous equilibrium is at high potential there is an excess, or if it is at low potential there is a deficiency, of destructible substance in the organ, as compared with the amount characteristic of autonomous equilibrium. When a stimulus is withdrawn after a state of allonomous equilibrium has been reached the organ tends naturally to return to the autonomous level, thus reversing the chemical motion which was brought about by the stimulus. All motion of this sort is change from one state of equilibrium to another and is itself allonomous or autonomous according as it is determined by the stimulus or by the internal vital forces, respectively.

Hering's theory of the psycho-physics of response supposes that sensation is conditioned by definite changes in the equilibrium state of the appropriate sense-organ.[2] A stimulus causes sensation by disturbing the equilibrium and thus inviting the metabolic process to seek a new level, but when the latter is found sensation vanishes. When the stimulus is removed the living substance automatically returns to its original state, and during this process, also, there is sensation, usually of a type opposite in quality to that caused by the stimulus. Such shifts in the point of equilibrium always imply alterations in the sensitivity or "potential" of the living substance.

II. The Criticism of Hering's Theory

The theory of the metabolism of response above outlined has some remarkable merits and almost as many remarkable demerits. On the credit side we may count its power to explain the adaptation of sense-organs to specific stimuli, the phenomena of after-images, and the relation of antagonism which exists between different stimuli in certain departments of sensation.

However, Hering's theory has been justly subjected to severe adverse criticism.[3] In the first place, a large part of its explanatory power depends upon the supposition that stimuli encourage anabolic as well as katabolic processes in protoplasm. The arguments which have been brought forward against this supposition are more general than we should wish, but they are nevertheless fairly convincing. Anabolism

is essentially a repair process, a restitution initiated by internal forces to compensate for the destructive effects produced in the organism by stimuli.

There are other more serious objections to Herin's views. One of these is found in the fact that, contrary to the demands of the theory, continued constant stimulation does not invariably end in the disappearance of sensation. Moreover, the present writer has shown experimentally that, at least in the case of vision, although changes in the equilibrium point occur during the process of stimulation, by far the greater part of our seeing must go on under conditions which are approximately those of stable equilibrium. In addition, Hering's theory may be correctly accused of formalism. It takes too little cognizance of the concrete concepts of modern chemistry and physiology, which readily fit into the general form of the theory and at the same time render it more realistic.

III. A Revision of the Chemical Response Theory

It is impossible to seriously question Hering's fundamental postulate, the statement that organic matter is characterized by concomitant destructive and constructive chemical change, and that active organic response must be determined by an augmentation of one or the other of these processes, under the influence of the stimulus. If chemical change occurs it must consist in the synthesis or in the decomposition of some substance, and this substance must have a certain definite *concentration* in the living matter which is being considered. Let us designate this substance by S, and its concentration by s. For convenience we shall confine our attention to the processes which occur in a single living cell, and we shall define s as the absolute quantity of the substance S which is contained in the particular cell which we are to study.

Now since we intend to regard the katabolic phase of metabolism as the only one which is directly affected by the stimuli which act upon the cell we may simplify the general mechanism concerned by supposing that no synthetic changes at all occur within the cell; but that the substance S is supplied to it ready-made, by the blood or lymph. From a formal point of view this *nutrition* of the cell is equivalent to a synthetic process going on within it, since it tends to bring about an increase in the concentration of the substance in the cell. Accordingly, it can be represented by the derivative, ds/dt,

the rate of change of the concentration of S with respect to the time. The katabolic changes within the cell are also representable by a similar derivative, with negative values. For purposes of abbreviation let us write:

(a) $$ds/dt = \dot{s}$$

Now we must suppose that in an undisturbed cell which is metabolically stable the processes of nutrition and katabolism are equal and opposite. Hence, if the rate of nutrition is a, and the rate of katabolism k, we have:

(1) $$\dot{s} = a - k = o;$$

which may be designated as the *equation of rest.* This equation does not mean that the living substance is inactive in the rest condition but merely that its activities are balanced in such a way as to produce no resultant or average change in the concentration of S. The physical chemist expresses practically all states of apparent chemical quiescence as equilibria of this general sort.

It is in accordance with common-sense, as well as with the law of "mass action" in chemistry, to suppose that the rate of "autonomous" decomposition, k, of the substance S will depend upon the amount of S which is present to decompose, that is, it will depend upon the concentration, s. If the relationship in question is a purely chemical one, it will be a proportionality,[4] so that:

(2) $$k = c_k s,$$

where c_k is a constant, the "reaction" which is concerned being of the so-called *irreversible* type and hence being independent of the accumulation of waste products. We shall speak of this expression as *the equation of self-excitation.*

Now, in order to avoid the difficulties encountered by Hering, let us assume that the stimulus, I, always produces a *katabolic change* in the substance S, and has no direct effect either upon the rate of nutrition or upon possible anabolic processes. For simplicity's sake we will make the probable assumption that the increase in the rate of katabolism engendered by the stimulus is proportional to the intensity, i, of the latter, so that if this increase is d, we have:

(3) $$d = c_d i s,$$

which may be called *the equation of response.* d is proportional to s for the same reason that k is so proportional (see equation (2), above).

Thus, when a stimulus is acting, we have, from (2) and (3) and the definition of $\dot{s}$:

(b) $\dot{s} = a - k - d$ or

(c) $\dot{s} = a - c_k s - c_d i s$ or

(4) $\dot{s} = a - (c_k + c_d i)\ s$

This will be known as the *equation of total activity*. The values of $\dot{s}$ which it includes are, of course, in general not the same as those of (1), above.

The term, a, represents the repair, while the term, $(c_k + c_d i)\ s$, represents the destructive process. The first part of the latter stands for what Hering would call autonomous katabolism (or dissimilation), the second part for what he would designate as allonomous katabolism. a is, of course, autonomous.

Now it is obvious that if the second term, above, is larger than the first, $\dot{s}$ will have a negative value, and since $\dot{s}$ is the rate of change of s, this means that s will constantly decrease. But as s decreases the term $(c_k + c_d i)s$ must decrease also, and this change will obviously go on until the last mentioned term becomes equal to a, at which time $\dot{s}$ will become zero, and s will thus cease to vary. In this way there will be established an equilibrium analogous to that represented in equation (1)[5] but involving a stimulus intensity, i. It corresponds, then, with the allonomous equilibrium at low potentid of Hering's theory.[6] Since by definition of an equilibrium state we have: $\dot{s} = o$, for such an allonomous equilibrium we can write:

(d) $\dot{s} = a - (c_k + c_d i)\ s = o$ or

(5) $$s = \frac{a}{(c_k + c_d i)},$$

the equation of equilibrium sensitivity, which expresses the concentration of the substance, S, in terms of the intensity of the stimulus, I, and certain constants.

It is obvious from the form of equation (5) that the greater the intensity of the stimulus the lower must be the concentration of the substance, S, at equilibrium. Since by equation (3) the degree, d, in which the living substance responds to a stimulus of intensity, i, is proportional to s, s may evidently be appropriately defined as the *sensitivity* of the sense-cell. *Hence we arrive at the general result that the higher the intensity of a stimulus which produces allonomous equilibrium, the lower the point to which the sensitivity of the organ is*

reduced. This result is in accord with the facts of response in many departments of sensation.

Now, in accordance with equation (4) the katabolic component of the process within the sense-cell is always:

$$q = (c_k + c_d i)\ s \tag{6}$$

and since by the definition of an equilibrium state,

$$q = a, \tag{e}$$

it follows that under the assumptions thus far made the rate of the katabolic process at any allonomous equilibrium is independent of the intensity of the stimulus responsible for that equilibrium, and is, accordingly, the same as that at autonomous equilibrium.

The question may now be raised as to whether the repair process, a, actually does remain constant during stimulation. It is in harmony with our general knowledge of vital behavior to suppose that marked destructive changes in the substance of a sensory cell will be accompanied by a *positive increase* in the restitutive process. As a matter of fact, the physiological situation which is involved in the process of nutrition makes it easier to assume that such an increase occurs than to support our previous, mathematically simpler, assumption of a constant repair.

A cell is a portion of space marked off from the lymph in which it is immersed, by a membrane. Through this membrane the sensitizing substance must pass. It is probable that if the molecules of the substance in question can pass into the cell they can also pass out. Since the process under consideration is essentially one of osmotic diffusion the rate at which the substance is penetrating the cell at any instant must depend on its concentration in the lymph, while that at which it is leaving the cell must be proportional to its concentration inside.[7] The net rate of increase in concentration of the substance in the cell will, of course, be the difference between the income and the outgo, and this difference is identical with the a of our equations. Hence, if we suppose the concentration of the substance, S, in the lymph to be a constant we can write:

$$a = r - c_r s, \tag{7}$$

the equation of compensation, where r is the rate of income, and $c_r s$ is the rate of outgo. s, of course, is the concentration of S within the cell. Under the conditions, $c_r s$ must always be less than r.

It is obvious that if this equation is true the rate of nutri-

tion will not be constant, but will increase as the sensitivity, s, of the cell decreases. If we substitute the above value of a in equation (4) we get:

(f) $$\dot{s} = r - (c_r + c_k + c_d i)\ s$$

or, for equilibrium:

(8) $$s = \frac{r}{(c_r + c_k + c_d i)}$$

(The equation of equilibrium sensitivity for compensating response) an equation which has the same general form as (5).

If we now substitute this value for s in equation (6), we have

(9) $$q = \frac{r\ (c_k + c_d i)}{(c_r + c_k + c_d i)}$$

(The equation of equilibrium excitation for compensating response) which states that the rate of the katabolic process at allonomous equilibrium is higher the higher the intensity of the stimulus, i being the only variable on the right-hand side of the equation. From the form of equation (9) it is obvious that q must always be less than r. Equations (7)-(10), inclusive, characterize what may be designated as a *compensating response.*

Expression (9) holds for autonomous as well as for allonomous equilibrium, and for the former since: $i = o$, the expression reads:

(g) $$q = \frac{r\ c_k}{c_r + c_k}$$

The term on the right-hand side of the equation may be described as the *non-compensative response,* since it is natural to say that the compensation is zero when the stimulus is zero. It is thus possible to define the *compensation* itself as the difference between the non-compensative and the actual response under a specified stimulus, i, as follows:

(h) $$u = r\left(\frac{c_k + c_d i}{c_r + c_k + c_d i} - \frac{c_k}{c_r + c_k}\right)$$

When $i = o$, $u = o$; when i is very large $(= \infty)$ $u = r\left(1 - \frac{c_k}{c_r + c_k}\right) = \frac{r\ c_r}{c_r + c_k}$ so that the compensation can vary only between the limits, o and $\frac{r\ c_r}{c_r + c_k}$, the latter term

representing the greatest difference in excitation which can exist between an autonomous and an allonomous response under equilibrium conditions.

Now whether or not a given process of response appears to be compensative must depend upon whether or not the value of u at equilibrium is sufficient to produce a *threshold difference* between the self-excitation and that brought about by the stimulus. In other words, if Δq is the difference limen in question, in order that the response should appear compensating the relation $u > \Delta q$ must hold. If $\left(\frac{r\, c_r}{c_r + c_k}\right) < \Delta q$ the response will always appear to be non-compensating.

When any stimulus whatsoever is applied to a sensory cell in allonomous equilibrium the excitation first rises, and then begins to fall; and it will drop finally to an equilibrium level which is determined by the intensity of the stimulus itself, in accordance with equation (9). The excitation under such conditions of allonomous equilibrium must always be considerably less than that which was produced by the stimulus at the outset. Thus, while a stimulus may at first cause a sensation which differs appreciably from that which is characteristic of the self-excitation of the sensory system concerned, adaptation may so diminish this difference that it becomes, at equilibrium, wholly indistinguishable. When such is the case the response will be to all intents and purposes non-compensating. For a higher intensity of stimulation, however, the equilibrium excitation will be greater, and hence for stimuli of this description the compensation will be apparent. Accordingly, we may argue that in all departments of sense in which the chemical mechanism which we have been considering is active, evidences of the existence of compensating response are not to be expected for relatively weak stimuli. Just how strong a stimulus must be in order that compensation should appear in connection with it must depend upon the magnitude of the difference threshold for the sense under consideration, and upon the nature of the constants in equation (h). It is obvious from the form of the equation in question that for $c_r = o$ the compensation will be zero. The larger c_r the greater will be the compensation for a stimulus of given intensity.

Equation (9) asserts that the excitation at allonomous equilibrium increases as the intensity of the stimulus increases, but the relation which is stated to hold between the two is not a proportionality but an asymptotic function more or less

logarithmic in form. Consequently *equation* (9) *may be regarded as a statement of Weber's law in so far as this law applies under equilibrium conditions.* However, it is the writer's opinion that the Weber relationship—which is known to be only approximately logarithmic—holds not only between the intensity of the stimulus and that of the excitation in the receptor, but for every transition in the sensory-cerebral system.

Let us now consider the somewhat more difficult problem as to the exact process which occurs when a stimulus is applied to an organ whose substance is in autonomous equilibrium. For simplicity's sake we shall confine ourselves to the case of non-compensating response, but the results will be typical of compensating response as well. In accordance with equation (3), when a stimulus, i, is first applied to a sense-cell in autonomous equilibrium it increases the rate of katabolism by an amount: $d = c_d is$, if s is the concentration of the substance, S, under the conditions of this equilibrium. The equilibrium itself is thus destroyed, so that s decreases, and with it d, and a new *allonomous* equilibrium point is reached, the conditions of which have been described above.

The first result which appears, then, is that the effect produced by the stimulus is greatest in the beginning, decreasing relatively rapidly at first, more gradually later on, until it finally reaches a level at which it is constant. In mathematical language, the effect produced by the stimulus decreases *asymptotically* towards an equilibrium condition determined by the intensity of the stimulus.

By use of the calculus it is easy to derive from the above equations the following expression, which shows how the rate of the katabolic process in the stimulated cell varies with the time:[8]

$$q = a + \frac{1}{\mathbf{e}^{(c_k + c_d i)t}} \tag{10}$$

where $\mathbf{e}$ is the base of the natural logarithms, and t is the time which has elapsed after the application of a stimulus of constant intensity, i. Examination of this function shows that as time goes on the value of q approaches a as a limit, but theoretically would only reach it after an infinite period. If we put: $t = \infty$, the term containing it becomes zero, so that: $q = a$, which is obviously the condition for equilibrium. As with all curves of this sort, the rapidity with which the limit

is being approached is less the greater t, and in the region of very large values of t is practically zero.

Expression (10) may be named *the equation of adaptation.*

In a similar manner we can calculate an expression which shows how the autonomous katabolism will increase after the stimulus is removed. The exact form of this expression varies, of course, with the value of s which corresponds with zero time. It is simplest if the value selected is: $s = \frac{a-1}{c_k}$, when it becomes:[9]

$$q = a - \frac{1}{e^{c_k t}}, \tag{11}$$

the equation of recovery. It is obvious that for small values of t the change in the term, $\frac{1}{e^{c_k t}}$ will be relatively rapid, while for large values it will be relatively slow. After the passage of an infinite time the term becomes zero, so that, once more, $q = a$, the condition for equilibrium.

Accordingly, the recovery process, like the process which accompanies stimulation, is asymptotic. The sensitivity of the living substance increases rapidly at first, and then more slowly until autonomous equilibrium is practically reached.

Equations (10) and (11) have been calculated on the assumption that the repair process is constant, as represented in (1)-(7), above. If, on the other hand, equation (7) is introduced into the calculations, expressions will be obtained which differ from (10) and (11), but not in an essential manner.

IV. Interpretation of the Theory

It is obvious that the equations derived above offer an approximate representation and rationalization of the processes of rest, stimulation, fatigue and recovery from fatigue, which occur in various sense-organs. In our subsequent discussion *we shall regard sensation as dependent upon the intensity, q, of the katabolic process at any time.*

Certain of the senses show what may be called *self-activity,* as illustrated, for example, by the familiar "idio-retinal light" in the case of vision. The generic law of such spontaneous excitation is given in equation (2). The apparent absence of this unstimulated activity in some sense departments may be accounted for if we suppose that the value of c_k in these de-

partments is so small that the corresponding sensation falls below the threshold. Another possible explanation for the seeming lack of unstimulated activity may be found in the fact that in many cases an *antagonism* exists between two or more simultaneously active sensory mechanisms, so that the unstimulated activity of one (or more) would wipe out for consciousness the effect of the equivalent unstimulated activities of the others.[10]

The equation of response (3), represents the process of active stimulation while the equation of compensation (7), shows how the rate of repair varies with the sensitivity; (2) and (3) and (7) may be regarded as the fundamental and essential postulates of the theory. It is upon these postulates that the other equations, expressing the conditions of metabolic equilibrium, are directly dependent.

The equation of adaptation (10), shows that when a stimulus of intensity, i, is applied to a sensory cell the intensity of the response is not constant, but decreases as the time after the application of the stimulus increases. This decrease, however, itself decreases with the time, so that ultimately a point is reached at which the intensity of the response is practically constant. This condition is that of *equilibrium* with respect to the particular intensity of stimulus which is active. The relation which exists between a given intensity of stimulation, i, and the corresponding "equilibrium sensitivity," s, of the sensory cell is shown in equation (5), or, for compensating response in (8). It is clear that these equations, which are derived mathematically without further assumptions from (2) and (3), and, for compensating response (7), offer a rationale of the phenomena of sensory adaptation. The equation of recovery (11), on the other hand, which has a similar derivation, represents the process by which the cell returns to the non-adapted state.

The theory of metabolic equilibria above outlined is not presented as an exhaustive analysis of the relations involved in the metabolic process. It is offered simply as a crude generalization of the most fundamental principles underlying these equilibria, and hence can be regarded only as a first approximation to the truth. But, as such it must have a certain value.[11] Crudity of theory is more permissible in a field of measurement, such as psycho-physics, in which mean variations are large than in one where statistical procedure is a less essential part of the methodology.

The nature of further details of the metabolism of response which tend to make the situation more complex than we have

represented it above will be discussed in the appropriate context below.

For convenience in our discussion let us assign names to the variables and constants employed in our mathematical reasoning, as follows: (1) s = the sensitivity, (2) $\dot{s}$ = the resultant activity, (3) a = the repair, (4) k = the self-excitation, (5) c_k = the constant of self-excitation, (6) d = the response, (7) c_d = the constant of response, (8) c_r = the constant of repair, (9) u = the compensation, (10) i = "the stimulus" (stimulus intensity), (11) q = the excitation, and (12) t = the adaptation, or recovery, time.

The characteristic phenomenon of metabolic response is *adaptation. Adaptation may be rigidly defined as a specific but temporary reduction in the sensitivity of a sensory cell under the action of a stimulus of constant intensity.* It is the main thesis of this paper that the phenomenon of adaptation is the most important one which sensory psychology has to consider, and that a careful study of the laws of adaptation in the different departments of sense promises to be the most fruitful means of ascertaining the mechanism operative in these departments. Undoubtedly these mechanisms are not the same for any two senses, but certain general principles must hold for all of those senses which have the same general basis, such as, for example, the chemical. Both the resemblances and the differences between the laws of adaptation in the several sense departments should prove illuminating towards the determination of the exact mechanisms of the senses in question.

V. The Applications of the Theory

Let us now enquire to what extent, if at all, the theory of metabolic response as we have developed it is applicable to the several senses, as we now know them.

We should not rashly assume that all of the senses have the same mechanism, or even that they are all chemical. If adaptation occurs in a particular sense, and if the reduction of sensitivity which this implies depends in the general manner expressed by our equation of adaptation (10) upon the intensity of the stimulus, we shall have reason to suppose that the mechanism of this sense is chemical, and that the theory of metabolic equilibria will apply to it. Such adaptation, however, must bear the ear-marks of a peripheral process, and it must not be permanent in the absence of the stimulus. A sense in which there is no adaptation, or in which what adap-

tation does exist seems to be an adaptation of the attention, or to depend upon physical injury to the sense-organ, probably does not directly involve metabolic processes.

Fatigue may occur in senses which are not chemical, since all vital structures are, so to speak, tender, and when subjected to intensive or continued stress tend to break down, at least temporarily.[12] But the laws of such fatigue should be different from those characteristic of metabolic adaptation. Fatigue of this sort would not be specific with respect to the stimulus and it would probably not show equilibria. Moreover, it would be very much slower in recovery than chemical fatigue.

In how far adaptation of the sort which is typical of metabolic response may be simulated by processes which are not strictly chemical cannot be considered in detail in this paper. The type of adaptation in question, as illustrated, for example, in the case of vision, seems to depend upon the fact that something is being "used up" in the process of excitation. One naturally thinks of this "something" as a substance which is present in the beginning in a definite quantity, thus determining the special sensitivity of the sensory cell, and which is chemically decomposed by the action of the stimulus. Energy might also be stored and reduced in level during stimulation, but it seems hardly reasonable to suppose that the sense-cell needs to supplement the energy of the stimulus with energy of its own. Even if the sensitivity of the cell depends upon the amount of specific substance present within it this substance might conceivably be reduced in concentration asymptotically by some process other than that of chemical decomposition, such as for instance,—in the sense of touch —the migration of molecules or ions through a membrane under the influence of increased pressure. This last mentioned process would follow a law similar to our equation of adaptation.

In all investigation of this sort we are dealing in probabilities. However closely the phenomena which we observe may harmonize with deductions from our hypotheses, it is always at least remotely possible that another hypothesis would explain them as well, if not better.

With this digression let us return to the applications of our theory to the facts of sensory response.

The process of nervous conduction, Hering to the contrary notwithstanding,[13] is probably not a metabolic process. Although the changes which occur during the transmission of

the nervous impulse are no doubt molecular they depend in all probability upon the displacement of ions rather than upon decomposition or synthesis.[14] If these latter processes occur in the course of propagation they are probably immediately reversed. Hence we need not look for adaptation in the conductional aspect of sensory response, but must seek it in the characteristic processes of the sense-organs.

A sense in which adaptation is certainly not a characteristic phenomenon is that of *sound*. Stimulation of the ear with a sound of constant intensity does not result in a decrease in the apparent intensity of the tone or noise, once the *tensor tympani* is adjusted, if the attention is unwavering.[15] This is what we should expect if Helmholtz's resonator theory of audition is correct, since, according to this theory the peripheral mechanism of this sense is purely physical. The theories advanced by Ewald and Meyer,[16] to explain auditory response are also stated in purely mechanical terms, and would not lead us to expect in audition any of the effects which would be characteristic of a chemical sense.

It seems likely that the *labyrinthine senses* are also mechanical, although it is difficult to say whether or not they show adaptation. The experiences of persons who are susceptible to sea-sickness seem, however, to point in the direction of their non-adaptiveness. Adaptation to the motions producing seasickness often occurs, but the length of time required for it to appear shows that it is not sensory.

If we turn to sensations derived from the skin, we find that although there are ample evidences of adaptation in the case of touch and temperature, the *sense of pain* appears to be non-adaptive.[17] Hence we should conclude that the last-mentioned sense is not chemical in its mechanism, and this conclusion is in harmony with the reasonable supposition that pain is due to the direct stimulation of the free nerve endings in the skin (and elsewhere).[18] According to this view, pain has no characteristic peripheral mechanism, and its non-adaptiveness is one with that of pure nervous tissue.

The *sense of touch* or pressure, on the other hand, is remarkably adaptive.[19] So far as extant experimental evidence goes to show, adaptation of touch follows the general laws contained in our theory of metabolic equilibria. That spontaneous excitation exists in the case of touch is probable, and is the basis of Fechner's theory of tactual space.[20] From the point of view of perception, however, the corresponding sen-

sations *mean* the absence of pressure or of an outside stimulus. If for relatively weak stimuli the response of all touch cells finally reduces approximately to the level of the self-excitation, k, (equation (1)), we have an explanation for the fact that diverse pressure stimuli which are constantly effective ultimately become indistinguishable from one another, and from the absence of a stimulus. This principle seems to apply to pressures which do not exceed a certain maximum, such as the contact of the clothes with the body. For higher intensities of stimulation the sensation seems to remain above the neutral level for a long time, as we should expect from our theoretical discussion of compensation, above.

The fact that self-excitation exists in the sense of touch is indicated by the experience which we have upon the removal of a pressure stimulus to which we have become completely adapted, or for which the touch cells are in equilibrium. Since in accordance with the equation of equilibrium sensitivity (5), such an equilibrium means a reduction in the sensitivity of the cells in question the removal of the stimulus must be followed by a marked decline in the intensity of the sensation yielded by these cells, for equation (2) makes the self-excitation of the cells depend upon their sensitivity at the time. This fall of the local response below the normal autonomous equilibrium response provides the basis for our perception that "something is lacking."[21] The disappearance of this feeling as time goes on is accounted for in the equation of recovery (11), which demands the return of the sensitivity of such an adapted region to the normal.

The *muscular and articular senses* seem to be very closely similar, in their mechanism, to the sense of touch. Presumably, like the latter, they are chemical in nature, but nothing definite is known concerning their adaptation processes.

As we have already stated, Hering's theory of response metabolism has been specifically applied by its author to the *sense of temperature*.[22] According to Hering's view, heat favors katabolism in the temperature end-organs, while cold favors anabolism, the corresponding sensations being concomitant with an alteration of the equilibrium point from higher to lower, and from lower to higher, respectively. All equilibrium conditions yield the absence of temperature sensation.

It is clear that this scheme accounts very nicely for the balance which exists between the sensations of heat and cold, and especially for the peculiar facts of temperature adaptation. Everyone is familiar with the fact that a decrease in the sen-

sitivity of the skin to heat means a corresponding increase in its sensitivity to cold, and *vice versa.* However, Hering's theory not only violates the canons of general physiology by joining a definite sensation (that of cold) with an anabolic process,[23] but it also explains the relations of the two temperature responses in terms which, although simple, are inconsistent with the demonstrated separate localization of " heat and cold spots."

If, then, we suppose that response for heat and cold occurs in different end cells, and that, moreover, they are both dependent upon the augmentation of certain katabolic processes, we have to account for the obvious antagonism which exists between them by means of an additional assumption. Heat and cold appear to have been correctly described by Hering as *antagonistic sensations.* As we shall see shortly, they are not the only sensations which belong to this class.

The nerve dissection experiment of Head and Rivers[24] has shown that there are at least two independent systems of temperature sensibility. The system comprised by the heat and cold " spots " gives no evidence of adaptiveness, and the reason for this is easy to see, in as much as the end-organs of this system are insensitive to temperatures lying between 26°C and 37°C. Since the curves of sensitivity of the heat and cold spots do not intersect, the temperature system which they make up can have no " physiological zero," and it is the shifting in position of such a physiological zero which constitutes ordinary temperature adaptation. The limits of sensitivity in this system are probably set by the precise nature of the chemical processes which characterize the end-organs. According to our view the heat and cold sensations yielded by the " spots " are antagonistic, like those of the " epicritic " system, but since only the latter show a physiological zero, it is only in the epicritic system that temperature adaptation can produce a qualitative shift in the sensibility.

Several of the experiments performed by Head and Rivers show that simultaneous stimulation of adjoining heat and cold spots result, under the appropriate conditions, in the inhibition of the heat sensations by the cold, or vice versa.[25] As the antagonism between these two sensations obviously cannot exist in the end-organs, as demanded by Hering's theory, it is necessary to assume that it has a central, or at least a *sub-receptoral* location. Let us assume, then, that the arrangement of the temperature nerves is such as to balance " heat " impulses against " cold," so that the intensity of one impulse

is always subtracted from that of the other before any effect is produced in consciousness.[26]

Thus, if q_h is the excitation of the heat sense at any given time, and q_c is the simultaneous excitation of the cold sense, in a specified region of the skin, the effect upon consciousness will depend upon the arithmetic magnitude of their difference:

$$q_t = q_h - q_c, \tag{12}$$

the quality of the sensation being "heat" if the sign of q_t is positive, and "cold" if it is negative. If this hypothesis as to the relationship which exists between the heat and cold excitations be added to those of our theory of metabolic response it will be seen that this theory offers a satisfactory explanation for the phenomena of temperature adaptation so far as they are known at present.

The nature of temperature response is such that a stimulus is never absent. There is no physical zero for cold and the physical zero for heat never occurs in the environment of organisms. However, for purposes of exposition, we may define a "state of rest" of the temperature system in which

$$q_t = q_h - q_c = o. \tag{g}$$

If the temperature is now increased, q_h becomes larger and q_c smaller, in accordance with the equation of total activity (4), and hence a sensation of heat will be experienced. But the alteration which has occurred in the nature of the stimulus disturbs the equilibrium of both the heat and cold sensory-cells so that the excitation of the former gradually sinks in accordance with the equation of adaptation (10), while that of the latter gradually rises, as demanded by the equation of recovery (11). When equilibrium is re-established in both cells the equation: $q_h = q_c$, must again hold, so that $q_t = 0$. Although the temperature still remains at the higher point the sense of heat has vanished.[27]

In an entirely analogous manner it can be shown that if the temperature is lowered from this, or any other point for which equilibrium has been reached, a sensation of cold should be experienced until equilibrium again sets in, at which time the sensation will disappear.[28]

These deductions from the theory are obviously in general harmony with the facts of temperature adaptation. The deductions in question are based upon the assumption that the "repair," a, is a constant. However the fact that there is a limit (about 11°C.) below which complete adaptation to cold does not occur, and another (about 39°C.) above which complete adaptation to heat is reported to be unattainable, seems

to show that, as in the case of touch the response is really "compensating," but that for the lower intensities of stimulation the compensation falls below the threshold. However, the experimental evidence is still too vague to permit surety upon this point.[29]

The sense of *smell* has long been regarded as a characteristically chemical sense, and there is no sense in which adaptation is more in evidence. There seems to be no moderately intense stimulus to which the olfactory cells will not become completely adapted in a relatively short time.

The fact that there is no manifest self-excitation in the case of olfaction seems at first sight to argue against the view that this sense is subject to our theory of the metabolism of response. However, the objection is not a fatal one, for two reasons: first, because there is evidence that antagonism exists between various phases of olfactory response, so that one species of self-excitation may blot out another; and, *second*, because the equilibrium excitation may lie below the threshold. If this latter supposition were made, an explanation would immediately be provided for the completeness of adaptation to all moderately strong stimuli, since for such stimuli the compensation may be insufficient to raise the equilibrium point above the absolute threshold. According to Nagel[30] complete adaptation does not occur in the case of very strong stimuli, a fact which is again corroborative of our theory of compensative response which demands that for higher intensities the excitations should never fall to a neutral level. Other aspects of olfactory adaptation are in harmony with our theory.

However, the writer holds the opinion that the mechanism of olfaction is a very special one and, although chemical, depends upon conditions which differ from those of metabolic equilibrium. He hopes to discuss this view in a later paper. But it is worth while to note that if olfactory response should ultimately turn out to be made up of component nervous activities,—as in the case of temperature sensation—we should probably have to deal with the relation of antagonism represented in equation (12) above, expressed, of course, in olfactory terms.

In the sense of *taste* adaptation is a well proven phenomenon In this sense, also, we find the relationship of antagonism between the separate qualities which are involved, although the antagonism is perhaps less well defined than in the temperature sense.[31] The four component sensations of "sweet," "sour,"

" bitter," and " salt " appear to be balanced against each other in such a way that the first is to a greater or less degree antagonistic to each of the others, the distinctness of the antagonism to " sweet " increasing in the order in which the latter are named.

It has appeared in the study of the temperature sense that adaptation to cold increases the sensitivity of the temperature system to heat, and *vice versa*. Similarly, it has been found by experiment that adaptation to salt raises the threshold for sweet. Not only this, but it appears that strong stimulation with salt may be followed by a sensation of sweet even in the absence of an adequate stimulus to such sensation. This latter is a negative after-image effect, and is immediately explained in terms of the theory of antagonistic sensations which we have outlined in connection with the sense of temperature and the possible application of which to olfaction we have just considered.

If self-excitations of the " sweet " and " salt " mechanisms exist these self-excitations must be equal and opposite in the state of rest, since in this state neither of the corresponding sensations is present although if it were not for the antagonism both sensations would be above the threshold. Adaptation to salt means a reduction of the sensitivity of the " salt " mechanism in accordance with the equation of equilibrium sensitivity (5). Consequently when the stimulus is removed the self-excitation of this mechanism must fall below that for the " sweet " mechanism, as demanded by the equations of self-excitation and of antagonism. This leaves a certain portion of the self-excited activity of the " sweet " mechanism unbalanced, the residue which is responsible for the negative after-image.[33]

Gustatory adaptation occurs slowly and for strong stimuli is never complete. Accordingly, gustatory response, if actually chemical in mechanism, must be to a high degree compensating.

The most careful of all studies of the phenomena of sensory adaptation have, of course, been made in the field of *visual* psycho-physiology, Hering, himself, having worked largely in this field. However, the phenomena of adaptation in vision do not appear to be such as completely to substantiate Hering's hypotheses concerning the exact mechanism of visual response.[34] These hypotheses suppose the visual system to contain three specific substances which in the state of rest have characteristic metabolic equilibria. Decrease in the concentrations of these three substances is accompanied by sensations

of red, yellow, and white, respectively, while increase is paralleled by the opposite sensations, green, blue, and black, respectively. Now the facts of "color mixture" undoubtedly demand an antagonism between the excitations underlying red and green, and between those underlying yellow and blue, but observation does not support the view that there is antagonism between black and white. For these last mentioned qualities, on the contrary, there is fusion. An attempt has been made by G. E. Müller to remedy this weakness in the theory, but however successful, the attempt can hardly save the doctrine from the general objections outlined in the second section of this paper.[35]

To avoid these objections the present writer has proposed certain alternative hypotheses which form the basis of a theory similar in general structure to that of Hering but, he believes, somewhat less formalistic.[36] According to the author's view, the retinal cones contain four separate substances which are capable of being broken down by the action of light. The rates of decomposition of these four substances are the variables which determine the degree in which the corresponding sensation resembles red, yellow, green, and blue, respectively. However, a sub-receptoral mechanism of antagonism is further postulated, in accordance with which equivalent excitations of the red and green substances eradicate each other and are replaced in the same proportion by a new excitation giving the quality, white. The same relationship is supposed to hold for the yellow and blue excitations.

Now if we suppose that in vision, as in the other senses, self-excitation of the component responses exists, we are forced to assume that those for red and green are equal and opposite, and that those for yellow and blue are in a similar relationship. Under this supposition the so-called idio-retinal light can be referred to the white excitation which results from these two sets of balanced excitations. Such exact balance holds for autonomous equilibrium or for the normal rest condition of the retina.

If the eye is stimulated by a light which increases one of two antagonistic excitations more than it does the other the result will be a sensation corresponding in quality to the most intensive component of the response. As time goes on the intensity of this quality—say red—should fall in accordance with the equation of adaptation, until if the response were non-compensating the excitation corresponding to it would finally again equal that of its less stimulated antagonist—the "green" substance. When this point had been reached the

sensation would be one of white or gray. If the stimulus were now removed the reduction in sensitivity of the "red" mechanism as compared with the "green," as demanded by the equation of equilibrium sensitivity, would cause its self-excitation to sink below that of the "green" substance, so that the quality, green, should predominate in the sensation which forms the negative after-image. Other things being equal, this sensation should be darker than the idio-retinal light, since the total activity is less than that which underlies that light.

The experimental study of visual adaptation proves it to follow the general equations of adaptation and recovery.[37] However, when we come to consider equilibrium conditions we find evidence that, at least for stimuli of fairly high intensity, adaptation does not proceed to a point at which the resultant sensation reduces to neutral gray. Consequently we are forced to assume that in the case of vision, as in most other senses, the response is compensating. Accordingly, the equations for allonomous equilibrium will resemble (8) and (9).

The curves of adaptation and recovery of vision have been studied both for the rods and for the cones of the retina, and have the general form demanded by our equations (10) and (11).[38]

In addition to the various sensations which we have considered above there is another psycho-physical process—or phase of activity—which shows in a most striking way the phenomenon of adaptation.[39] It may seem rather daring to assert that *pleasantness* and *unpleasantness* have a direct chemical basis, but that such is the case is certainly suggested by the existence of affective adaptation. The author has for some time been interested in the view that these fundamental and contrasted aspects of the psychical life—pleasure and displeasure—represent synthesis and analysis, respectively, in the chemical substance of specific cortical centers. He hopes to develop some of the implications of this not entirely novel view in another paper.

However, it is pertinent to note here that if this chemical theory of the physical basis of affection is correct the situation which it represents is not only one in which the fundamental equations of our general theory of chemical response should hold good, but is also one which very closely approximates that contemplated by the original katabolism-anabolism view of Hering. Hence, besides explaining the disappearance

of the affective tone of a perception or sensation by means of our equations of adaptation, we can account for the reversal of the tone which generally follows the removal of the conditioning stimulus, in terms of the "assimilation or dissimilation material" which the physico-affective process has piled up. Pleasant experiences mean the accumulation of synthetized substance in the cortical cells. If the external causes acting upon these cells are taken away this overbalancing mass of anabolic material will favor katabolism, and hence the well-known "affective reaction." In a similar way we can account for the pleasure of "relief" which follows the removal of a painful stimulus or stimulus complex. This is the Hering doctrine, pure and simple.

Affective adaptation is typical and complete only in certain forms of experience, namely those in which the affective tone seems to depend upon novelty. Where the affection is determined by an instinct or some other basic mental "complex" the pleasantness or unpleasantness may be long continued and almost non-adaptive. We must suppose that in such cases there is an external repair process which (as represented in equation (7)) tends to maintain the typical metabolic function of the cortical cell by continually supplying it with the requisite chemical substances, whether synthetic or analytic. The beauty of meaningless music or the unpleasantness of some novel odor, are examples of the affective process at its simplest. With repetition this beauty, or disagreeableness, quickly disappears through adaptation. On the other hand, the pleasure of the erotic consciousness, and the unpleasantness of organic pain are affective processes which are undoubtedly supported by massive and complex psycho-physical mechanisms, of the nature of repair. This latter type of affective response, then, is compensative, like the majority of the sensations. On the whole affection tends to be compensative for low intensities and sensation for high intensities.

VI. Summary and Conclusion

If it is true that the characteristic activities of organic matter are at bottom chemical it is important for the psycho-physiologist to investigate theoretically the relationships which exist between the processes of metabolism and those of sensation. Hering has done this with great generality and with significant results, but the development of physiological psychology since his views were proposed demands that the situation be reanalyzed and that his hypotheses be recast. Such is the purpose of the discussion which we are now summarizing.

Hering supposes that both of the balancing vital processes of anabolism and katabolism can be augmented directly by the action of a stimulus, and he believes that he finds an explanation of sensory response, adaptation, recovery, and especially of antagonism in the quantitative consequences of this supposition. These consequences constitute a theory of sensory equilibria, and according to Hering's doctrine sensation appears only in conjunction with changes in the position of these equilibria, shifts in opposite directions producing antagonistic sensations. However, the assumptions of this theory are inconsistent with the modern belief that the immediate process of stimulation is always katabolic, and many details in the consequences of the theory are at variance with fact.

Accordingly, an attempt is made to redevelop the metabolism of response along more modern lines. The postulates and the deductions from them are presented in mathematical form, and lead to a number of characteristic equations which are descriptive of the conditions and processes of simple chemical response. These equations are based upon the supposition that stimulation can directly influence katabolism only, and that the intensity of sensation depends upon that of the katabolic change in the sense-organ. However, a certain amount of katabolism is supposed to occur in the absence of a stimulus and this constitutes the " self-excitation " of the sensory system. On the other hand, the inherent repair process which necessarily exists as the ground of the katabolism may also be appreciably increased in the presence of a strong stimulus. When such increase occurs the response is described as " compensating."

The equations of response thus obtained are interpreted, and are then applied to the experimental facts of sensory psychology. Among these facts the most significant is asserted to be *adaptation*. As a result of our theoretical discussion we have been led to the view that adaptation may be used as a criterion of the presence of chemical mechanisms underlying sensation. The several senses are examined in some detail, with the outcome that those of touch, temperature,[40] motor activity, taste, and vision are found to be metabolic. The author expresses the opinion that the mechanism of olfaction is one peculiar to itself, although chemical, as commonly supposed. Audition and the labyrinthine senses appear to be purely mechanical and non-adaptive forms of response.

In the study of the senses of temperature, taste, and vision we find ourselves forced to explain the phenomenon of an-

tagonism between certain qualitative different stimuli. This is accomplished in the present discussion by means of a mathematical assumption which differs from that of Hering, but which leads to the same general results.

It is suggested furthermore that the affective processes have a metabolic ground in the activities of the brain, and that affective adaptation is evidence for this view.

Hering's theory, then, although mistaken in the particular form of its postulates, and hence unfortunate in its attempted applications, contains a great deal of general truth, and should receive the correction and special elaboration which it has been the purpose of the present paper only to begin.

APPENDIX

1. This theory is given in its most general form in:
   HERING, E. Zur Theorie der Vorgänge in der lebendigen Substanz. *Lotos,* IX., 1888.
2. See:
   HERING, E. *Zur Lehre vom Lichtsinne,* Wien, 1878, pp. 74-85.
3. See, for example:
   FICK, A. Kritik der Hering'schen Theorie der Lichtemfindung. *Sitzungsbericht der phys.-med. Gesellschaft.* Würzburg, 1900.
4. The equation given is a "mass action" equation. Like (3) it depends upon the fact that the chances that a certain number of molecules of the sensitive substance will be decomposed in a given time are proportional to the total number present.
5. See reference 1, above: *"Sonderabdruck,"* p. 2.
6. See reference 1, above: *"Sonderabdruck,"* p. 4.
7. It is obvious that equation (7) specifies the conditions of an equilibrium between the cell and the lymph with respect to a transfer of the substance, *S*. Such an equilibrium exists when the cell is emitting as many molecules of *S* per second as it receives. However, this condition does not necessarily imply that the concentration in the cell is the same as that in the lymph at this time. As a matter of fact, even in the unstimulated cell this equilibrium will never be realized on account of the autonomous katabolism which is going on within the cell.
8. The equation of adaptation is derived as follows: Take $(c_k + c_d i) = b$. Then, by (4) and the definition of s,

$$ds/dt = a - bs \quad \text{and} \quad -ds/dt = bs - a.$$

Integrating the last expression; we get

$$-\int \frac{ds}{bs - a} = \int dt + c \qquad \text{or}$$

$$-\frac{1}{b} \log (bs - a) = t + c$$

But $c = o$, so that, transposing;

$log\ (bs - a) = -bt$, or, in exponential form:

$$bs - a = e^{-bt} = \frac{1}{e^{bt}}, \text{ whence:}$$

$$s = \frac{1}{b}\left[a + \frac{1}{e^{bt}}.\right]$$

On substituting this value of s in (6), we get:

$$q = a + \frac{1}{e^{bt}},$$

the equation of adaptation.

9. The equation of recovery was derived in the following manner: From equations (a) and (c) we have, when $i = o$:

$$ds/dt = a - c_k s$$

Transforming and integrating, we get:

$$\int \frac{ds}{a - c_k s} = \int dt + c \qquad \text{or}$$

$$-\frac{1}{c_k}\ log\ (a - c_k s) = t + c$$

Putting this into exponential form, we have if $c = o$:

$$a - c_k s = e^{-c_k t} \qquad \text{or}$$

$$s = \frac{1}{c_k}\left[a - \frac{1}{e^{c_k t}}\right]$$

Substituting this in the equation, $q = c_k s$, we obtain:

$$q = a - \frac{1}{e^{c_k t}}$$

It is obvious, however, that the form of this function must depend to a certain extent upon the value of s for which t is taken as zero. If we place $t = o$ in the equation as written we have: $q = a - 1$, from which:

$$s = \frac{a - 1}{c_k}$$

so that for the equation in the form given the recovery time must be measured from the instant at which s has the above value.

10. *vide infra.*
11. The writer desires to state explicitly that the present paper is regarded by him merely as a preliminary attempt towards an application of the method of mathematical hypothesis to the problems of sensory response. It is his opinion that this method would prove exceedingly useful in psycho-physics, if its nature and significance were clearly understood. Mathematical reasoning need not be limited to subject-matter which is capable of exact measurement. Its most general utility lies in the development and expression of *types of interdependence* between variable quantities. So long as we can *recognize the type* in the phenomena to which the mathematical results are applied, these results have significance. The reasoning presented in the present paper is in every sense schematic, and the hypotheses are tentative, although they are employed with that degree of confidence which is essential in any courageous attempt to discover the truth.
12. *Cf.*, for example:
    SCHÄFER, K. L. Der Gehörsinn, in Nagel's *Handbuch der Physiologie des Menschen*, III, 1905, p. 512.
13. See reference 1, "*Sonderabdruck*," pp. 18 ff.
14. See, for example:
    LILLIE, R. S. The Relation of Stimulation and Conduction in Irritable Tissues to Changes in the Permeability of the Limiting Membranes. *American Journal of Physiology*, XXVIII, 1911, pp. 197-223.
15. For a definite denial of auditory fatigue, and a rather detailed discussion of the experimental evidence upon this point, see Schäfer, *loc. cit.*, pp. 506-512. A series of experiments to prove auditory fatigue, but with negative results, is described by:
    SEWALL, E. Zur Lehre von der Ermüdung des Gehörorgans. *Zeitschrift für Sinnesphysiologie*, XLII, 1907-1908, pp. 115-123.
    This investigator's method is the same as that of Urbantschitsch (1881) and Thompson (1881) who believed they had proven the existence of such fatigue.
16. MEYER, M. Theorie der Gerauschempfindungen. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, XXXI, 1903, pp. 233-247.
17. See:
    TITCHENER, E. B. *A Text-book of Psychology*, 1910, p. 154.
18. See reference 17, p. 157.
19. There is some dispute as to whether touch adaptation is due to peripheral or to central causes, since it increases in the case of certain lesions in the cortex. However, it is a fairly safe policy to regard a process as peripheral until it has been proven to be central. On this, and related questions, see:
    THUNBERG, T. Physiologie der Druck-, Temperatur-, und Schmerzempfindungen; in Nagel's *Handbuch der Physiologie des Menschen*, III, 1905, pp. 647-735.
20. FECHNER, G. T. *Elemente der Psychophysik*, 2te unveränderte Auflage, II, 1889, pp. 311 ff.
21. See Thunberg, *loc cit.*, pp. 668-669.
22. HERING, E. Der Temperatursinn; in Hermann's *Handbuch der Physiologie*, III, 1879, (2), pp. 415-440.

23. It should be noticed that here the usual criticism of the Hering theory is not supported by chemical analogy. In general, decrease in temperature certainly does favor chemical synthesis. However, there is no evidence that effects of this sort in the living organism can directly produce sensation.
24. HEAD, H., and RIVERS, W. H. R. A Human Experiment in Nerve Division. *Brain*, XXXI, 1908, pp. 323-451, esp. Chap. VII.
25. *Loc. cit.*, pp. 442-446.
26. BABÁK, E. Ueber die Temperaturempfindlichkeit der Amphibien. *Zeitschrift für Sinnesphysiologie*, XL, 1912, pp. 34-45, believes that he has evidence of a neural polarity of the heat and cold systems, in the nature of the reactions which heat and cold produce in the frog.
27. VOIGT, A. Ueber die Beurteilung von Temperaturen unter dem Einfluss der Adaptation. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, LVI, 1910, pp. 344-378, denies that temperature adaptation is complete, but it is to be doubted if the periods of adaptation which he employed in his experiments were adequate to prove his thesis.

    RUBIN, E. Beobachtungen über Temperaturempfindungen. *Zeitschrift für Sinnesphysiologie*, XL, 1912, pp. 388-393, finds that temperature sensations exist only so long as the temperature of the skin is undergoing change. He proved by thermometric methods that such change may continue under constant conditions, for as long as an hour.
28. The investigations of Rubin, quoted in the preceding note, proved that the intensity of temperature sensation is greater when the rate of change of the temperature of the skin is greater. This is in harmony, of course, with Hering's theory, and it can be shown mathematically that it is also consonant with the hypotheses of the present paper, can in fact be deduced from them.
29. Some doubt must be felt as to whether the limits given are actually applicable to the temperature sensations themselves, since the extremes of temperature pass over psychologically into pain.
30. NAGEL, W. *Handbuch der Physiologie des Menschen*, III, 1905, p. 613.
31. See Nagel, *op. cit.*, p. 643.
32. On these points, see Nagel, *op. cit.*, pp. 641-644.
33. Simultaneous as well as successive contrast occurs in the case of taste, but it is not our purpose to consider the basis of such contrast in the present paper, although it finds ready explanation in terms of the metabolic theory of sensory response. See the author's paper in the *American Journal of Physiology*, XXXII, 1913, pp. 34-36, for a statement of this explanation in the case of vision.
34. Hering's visual hypotheses are well stated in his *Zur Lehre vom Lichtsinne*, reference 2, above. For his discussion of visual fatigue and recovery, see:

    HERING, E. Ueber Ermüdung und Erholung des Sehorgans. Leipzig, 1891.

35. MÜLLER, G. E. Zur Psychophysik der Gesichtsempfindungen. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane,* XIV, 1897, pp. 1 and 161.
36. TROLAND, L. T. A Definite Physico-chemical Hypothesis to Explain Visual Response. *American Journal of Physiology,* XXXII, 1913, pp. 8-41.
37. For experimental data showing the nature of the curves, see:
    KRIES, J. VON. Die Gesichtsempfindungen; in Nagel's *Handbuch der Physiologie des Menschen,* III, 1905, p. 216.
    The curve of adaptation which is given has the right form if the relationship between the intensity of the stimulating light and the times of stimulation is taken into consideration. The curve of recovery is less satisfactory, but its lack of continuity throws doubt upon its validity.
38. In addition to the reference given in note 37, see, on adaptation in the cones:
    NAGEL, W. Helmholtz's *Physiologiche Optik,* 3te Auflage, II, pp. 282-283.
    On adaptation in the rods (visual purple) see the same, pp. 264-278. Also:
    PIPER, H. Über Dunkeladaptation. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane,* XXXI, 1903, pp. 161-215.
39. On affective adaptation see:
    TITCHENER, E. B. A Text-book of Psychology, 1910, pp. 229-230, and Lectures on the Elementary Psychology of Feeling and Attention, 1908, pp. 65-69.
40. Evidence that the cutaneous senses are chemical has been found by:
    MOORE, T. V. The Influence of Temperature and the Electric Current on the Sensibility of the Skin. *Psychological Review,* XVII, 1910, pp. 347-380.

ON THE PSYCHOLOGY OF POETIC CONSTRUCTION

An Experimental Method

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What is the peculiar coloring of consciousness and what is the particular correlation of mental elements which characterize the processes of the poetic imagination? Precisely how can the poet's actual construction of a poem be described in psychological terms?

No positive answer to these questions is attempted in this paper. I shall at present endeavor only to outline tentatively an experimental method, an adequate application of which will, I believe, yield concrete information concerning the workings of the creative imagination during the process of poetic construction, and thus contribute to fill a gap in present psychological knowledge.

My first interest in the problem was stimulated by Professor Titchener, under whose direction the Cornell Psychological Seminary during the year 1907-1908 studied the problem of imagination. "Imagination is virgin territory, and awaits as it invites the pioneer:—"[1] and if this judgment of Titchener's represents fairly the status of the structural element, the image of imagination, it is doubly true of the higher complexes of the imaginative consciousness, especially of the processes of "inspiration" and poetic construction. I shall preface my outline of the proposed method by referring very briefly to several other methods used for the study of imagination, claiming no completeness of survey whatever and undertaking no criticism, but touching on their main points only in order to relate them to the method here proposed and so to indicate some positive merits (but also some scarcely avoidable disadvantages) which it seems to possess for the experimental study of the particular problem before us.

To a not inconsiderable part of educated humanity, this sort of inquiry has always appeared in the nature of poetic

[1] E. B. Titchener, The Past Decade in Experimental Psychology; *American Journal of Psychology*, XXI, 1910, 417.

lèse majesté. For, while poetic construction has never ceased to interest mankind, the marvelous character of the poet's output has seemed to demand a mystical explanation. Mediocre humanity, regarding its mediocrity as normal, has seen in the prodigality of poetic genius a mark of super-normality, and has accordingly treated the poet as a god-inspired man, a madman divine. Witness the phrases 'inspiration,' 'divine fire,' '*poeta nascitur*,' and the poet's own traditional appeal to the muses. Plato writes in the *Ion*, "God takes away the minds of poets, and uses them as his ministers;" and Shakespeare:

> "The lunatic, the lover, and the poet
> Are of imagination all compact."

The bacchante is possessed by the deity; the poet is a priest of God; Handel sees Jehovah himself in writing the Halleluiah Chorus; Paganini's violin is devil-bewitched. This has been the popular explanation of the poet's work. Needless to say, on this basis we may be able to write poetry, but we can never explain the writing of it. Yet it must be confessed that even sober psychologists have often yielded to the lure of the mystical, and ended their chapter on imagination with a virtual confession of their inability to deal with it scientifically.

In the earlier psychology, of course, the imaginative faculty was discussed in a formal manner and was treated in a way calculated to fit it in the particular groove to which it was predestined by the logical demands of the philosopher's system: it was accordingly represented as thought involving internal intuition (Descartes), or as modification of sensation (Hume, Condillac), or else as the synthesis of reproduction operating in the dark chambers of the mind (Kant), and so forth.

The most cursory survey of the chapters on imagination in more recent psychological literature would reveal the absence of any agreement as to the nature of imagination, its relation to other mental processes, or its classification under some one general group of mental activity. Imagination is treated indifferently in connection with the representative, the affective, the volitional, or the higher thought-processes. James Mill styles it a mere train of ideas; Sully accentuates the choice of alternative combinations; James speaks of it as the recombination of previously experienced elements into new and original forms; Ladd stresses the teleological and lapses into mysticism; Calkins calls it the personal attitude

of a self; Wundt describes it as a perceptual form of intellectual elaboration; Höffding treats it as the power of concrete ideation; Ribot discovers affective, volitional, motor elements. One could write a paragraph composed wholly of citations from standard psychological treatises, which would describe imagination as being everything that a mental process can well be, and would find in it, as the essential factor, sensation, feeling, will, association, reproduction, recombination! This state of affairs characterizing the treatment of imagination is only emphasized when we reach the paragraphs touching on the poet's imagination. The chapter on poetic construction is yet to be written in modern psychology, and written it can be, of course, only on the basis of experimental study.

The process of poetic construction may be studied on the basis of an experimental study of imagery. Indeed the scientific study of imagination during the last hundred years has been very largely a discussion of mental imagery. Bonald, Egger, Taine, Ribot, Arréat, Dugas, Philippe, Binet, Paulhan, Peillaube, Souriau, Galton, Bain, Meumann, Wallaschek, and many more have studied the types of mental imagery, visual, auditory, kinaesthetic, verbal, after-images, memory images, images of imagination. A very promising investigation of this sort is represented by the Cheves West-Perky experiments, conducted at the Cornell laboratory, the publication of which[2] has attracted considerable attention. The West-Perky experiments, at which I had the opportunity of serving as an observer, were calculated to lay hold on the image of imagination and, by comparing it with the image of memory and with perception, to furnish experimental knowledge of the structural elements of the imaginative consciousness. This sort of study is decidedly more definite and more relevant to our problem than the conventional treatment of imagery in general; but, in applying its conclusions to the problem of creative imagination, care should be exercised lest an incautious interpretation prejudice at the very start the success of a study like ours. For, it seems to me, one is scarcely warranted in proceeding from an experimentally elaborated and grounded difference (or else lack of essential disparity) between the image of imagination and the image of memory or perception, to the declaration of a corresponding difference or similarity between the processes of creative imagination and memory or perception,

[2] *Amer. Jour. of Psychol.*, XXI, 1910, 422-452.

as the case may be. Would imagination cease to be a distinctive mental process if experimentation disclosed in it no structural elements other than those present in memory and perception? It may be possible that the poetic imagination is a unique elaboration of a wealth of material not different in structure from the stuff of memory and perception. The prosaic memory and the poetic imagination may be using the same alphabet of images, yet speak quite different languages. The problem of the poetic imagination, accordingly, requires an experimental knowledge, not only of *what* materials it uses, but also of *how* it uses them; how the poet combines usual conscious material in a most unusual way,—how, in the words of Browning's *Abt Vogler*, "such gift be allowed to man, That out of three sounds, he frame not a fourth sound but a star." To make it significant for the experimental study of our problem, therefore, the laboratory investigations of the image of imagination should be supplemented by a study of the process of poetic construction itself in such a way as to preserve its dynamic essence.

This attitude toward our problem is, to be sure, by no means new, and I shall discuss briefly what seem to me to be the several typical avenues from which the study of poetic construction has been or might be approached. Thus, we may study the faint manifestations of what appears to be a poetic consciousness in mediocre minds. We may, for example, preface our study by attacking the problem from the angle of aesthetic appreciation: read a poem to a class of high school or college students and ask them to report the imaginative processes experienced. Then, passing beyond the mere enjoyment, we may ask a class of boys or girls or adults to write a poem, and then tell us how they did it. How far can experimenting of this sort carry us towards our desired goal: the solution of the problem of poetic construction? The verses, of course, will be doggerel; the introspections at their best will accordingly be introspections concerning the doggerel-writing process, not concerning the process of *poetic* construction. For we have no reason to suppose that the radical features distinguishing the output of a dunderhead from that of a Dante may not indicate a corresponding difference in the working of their imaginations. If we are to study the poetic consciousness directly, we must first of all find our poet:

"Wer den Dichter will verstehen
Muss in Dichters Lande gehen."

We must go to the poet's own country; we must study him on his native soil, in his own element. But how?

As one reads over the literature on creative imagination, especially the more recent French contributions, one is impressed by what may be called its gossipy character. In book after book one reads entertaining bits about poets, painters, musicians:—the vagaries of Théophile Gautier and the De Goncourts, the whims of Baudelaire and Balzac, the eccentricities of Daudet, the passions and sufferings of Chopin and De Musset, the luxuriance of Flaubert and Massenet, the cynicism of De Maupassant, etc., etc. I would not in any way depreciate the great value of this sort of work. The more we know about poets, the nearer we get to understanding the poetic consciousness; but surely the genius of Gautier did not exhaust itself in wearing outlandish waistcoats, nor is the literary work of Carlyle explainable quite in terms of his over-indulgence in ginger-bread. How, then, is the psychologist of the poetic imagination to become something more than a compiler of literary anecdotes? Is he to spy upon the poet unawares, dog his footsteps, jotting down every word in an effort to discover the trick of his inspired craft? Or is he to deposit him in a laboratory, and direct him to write poetry to the accompaniment of a smoked-drum motor, with intervals between stanzas for introspection? Or is he to extract his secret with a questionnaire?

Important work of a preliminary character has been done and can be furthered in the form of collecting, digesting, and presenting in systematic form the utterances of great and lesser poets on the subject of their art; the self-revealing snatches of verse or prose passages in which the literary genius, Whitman-like, "celebrates himself;" or else the more elaborate attempts at creative introspection,—writings like Edgar Allan Poe's *Philosophy of Composition*, purporting to give the history of *The Raven;* the "Studies of My Own Creation" by the poet Otto Ludwig, which Richard Müller-Freienfels has recorded in his *Psychologie der Kunst,* and others. A carefully worded questionnaire sent to contemporary poets of unquestioned genius, asking them for introspections concerning their methods of creative work, would be likely to yield revelations most valuable to the student of the problem. Or, going still further experimentally, one could select a genuine poet and simply Bozwellize him, study his imaginative consciousness directly, and secure the best introspective reports possible. Such studies have been repeatedly made in France, notably Binet and Passy's accounts of French

dramatists, psychological reports of the literary work of Zola and Hervieu, and also Paulhan's record of the self-analysis of Roger Dumas, one of the younger French poets, containing an introspective history of the construction of two entire poems,—and most interesting reading it all makes too!

But all of these methods suffer from certain radical defects. Obviously we can not depend on a poet's self-revelational snatches of verse for the solution of our problem. One can borrow a couplet from Shakespeare or Shelley in order to illustrate vividly a conclusion already based on other grounds; but the psychology of imagination will not go far if it consists merely of poetical quotations. We can scarcely expect scientific exactness and accurate introspection from a poet who is expressing his inmost soul for other than laboratory purposes.

Far different is the case when the poet in a calm mood actually attempts to give an introspective account of his creative process. For that very type of mind which makes him a fine poet, makes him in most cases also a very bad psychological observer. Most of the poetic psychologizing along this line that I have read suffers from the irrepressible artistic temperament. The poet seems utterly unable to analyze himself with scientific objectivity. He sees things colored by his artistic preconceptions. He is either a mystic believer in the divine inspiration idea,—or else he is an Edgar Allan Poe type of a rationalist and tells you, step by step, just how he succeeded in deducing his great poem from his major premise. The student of imagination seeking light from the direct introspections of poets is thus obliged to steer his way between the Scylla of poetic mysticism and the Charybdis of irresponsible psychologizing. He is in the very palace of poetry, but the figures he meets all wear masks. Unless he can find his poet, he has little use for the introspections of mediocre minds; and, when he does find his poet, the latter turns out to be a most undependable psychological observer.

Laboratory experimenting with the actual process of poetic construction is confronted by radical difficulties, for the process is essentially spontaneous. Any conditions which interfere with the spontaneity of the creative imagination disturb the whole process. A poet can scarcely write genuine poetry and at the same time play laboratory observer. To be sure, a similar difficulty accompanies, in a measure, all psychological observing; but the very sense of partaking in an experiment, the very consciousness of having to report on

what is going on, may result, in the poet's case, in nothing poetic going on.

I should once more disclaim any inclination toward drastic criticism. Each of the methods just cited has, up to a certain point, justified its application by yielding genuine information on the subject. My point is that, even in combination, they are approximative only and do not touch the heart of the problem. Experimentation with the image of imagination leaves open the problem whether the creative imagination may not perhaps be essentially an unusual way of using usual conscious material. Studies of the imaginative consciousness of mediocre minds are not assuredly relevant to the problem, for the difference between the mental operations of the poet and of the verse-monger may be as radical as is the difference between their respective products. Anecdotical discussions of the poet's characteristics, whims, and mannerisms are liable to lead to conclusions more interesting than significant. The final solution of our problem demands an experimental study of the poet himself; yet the psychological value of the self-revelational utterances of poets is at least partially vitiated by the poet's apparently irrepressible tendency to go to one of two extremes, and either ignore introspective clearness and accuracy in his zest for rich poetic expression,—or else lapse into the sort of psychologizing of which the artistic temperament, lacking the sense of scientific responsibility, seems notoriously capable. And the spontaneity of the process of poetic construction seems jeopardized when we ask the poet to turn laboratory observer while actually creating.

Are we, then, to give up the attempt at experimental investigation and rest satisfied with the roundabout ways of studying the process, satisfied too with the surmises and conjectures that have up to the present time formed so large a part of the conclusions concerning the poetic imagination? While thus seeking a promising avenue of experimental approach to the heart of my problem, I happened some years ago to be reading a volume of the Russian poet Lermontov. It contained two facsimile reproductions from the poet's manuscripts. One was a clean-copied page, and I took some pleasure in studying Lermontov's handwriting and reading his lines. The other facsimile was a first draft, very different in appearance from the clean copy: scratched up, scored and interlined, corrected to the point of illegibility. It was while doing my best to decipher Lermontov's script that the idea occurred to me, which I have since endeavored to develop

and work out into a method for the experimental study of poetic construction.

Is not the problem of poetic construction a problem as to what goes on in the poet's consciousness while he is actually constructing? If some one had asked Lermontov how he wrote the poem in question, perhaps his answer would have been a wave of the hand, or a fanciful bit of irresponsible psychologizing. Yet this marked up copy in which word supplanted word, phrase phrase, and whole lines and stanzas were scratched up and crossed out to make room for their successors: is not this scarcely legible page a virtual laboratory record? If one could trace and establish the actual order in which pen-stroke followed pen-stroke, would not one be in a position essentially similar to that of the experimenter who reads on the smoked drum the zigzaggy record of his observer's reactions? Here are several false beginnings of a stanza, all suggesting different ideational and emotional contexts: the record of the progress from one to the other would be a record of the actual course of the poet's constructive process. Does the poet proceed with a clear view of his goal, and is his work one of selection from a rich store-house of image-combinations, as the typical British psychologists are inclined to believe? Or is the poet's work rather a progress from a vaguely felt mood to a mood more and more clearly experienced, a progress which is for the poet a voyage of discovery in which he really finds out what he is trying to say? Does the poem grow out of a catchy line or a jingle and is built around it; or is the pregnant phrase itself the child, the phraseologic elaboration of a central idea? Or, in case all of these processes are involved in the writing of genuine poetry, what mental factors are brought into play to emphasize one or another of these processes? All these questions, so puzzling at the present time and so likely to lead to mere theorizing, may find an adequate answer in the study of the experimental record represented by the poet's first draft. A poem's first draft is an objective record of a spontaneous process. In it the poet has, as it were, introspected while creating; step by step, the progress from mood to mood or from word to word or from image-combination to image-combination has found its inscribed record. Even the vicious scratches, the impatient or angry jabs with the pen, the idle lettering or sketching on the margin, the occasional smooth-running stanzas,—all indicate the progressive ideational-emotional coloring of the poet's consciousness. The

correct interpretation of the first draft of a poem would thus be as correct an answer as it is experimentally possible to give to the question: what went on in the poet's imaginative consciousness while he was writing this poem?

The claim contained in the last sentence sounds bold, and yet it will be found modest enough. For this method has undeniable disadvantages. To begin with, first drafts of genuine poetry are not to be found as easily as I for one was sanguine enough to suppose at first. Poets have a curious reluctance to preserve these dirty-looking scraps of paper. A poem is written; it must be copied in its finished perfection, and then the luckless record of its natal hour is usually thrown into the fire or is torn to bits. Browning, for example, always destroyed his first drafts. It is only by chance that the illegible scraps of paper are saved. Still, long and patient search, especially in large libraries, will be sure to bring to light a sufficiently large number of the desired records, although it must be added that a poet's first drafts are likely to become the property of private collectors and are thus hard to trace. One such collector, however, has been good enough to print Shelley's Note Books, in three volumes, containing a good deal of valuable material.

In the second place, the almost illegible material must be deciphered, transcribed, and interpreted in the light of what is known of the character of the poet in question, his general mode of work, the uniformity or otherwise of his handwriting, etc. Literary erudition and psychological interpretation must thus go hand in hand in this sort of work.

Yet, even after this part of the work has been done successfully, the experimental conclusions reached will be valid only for the poem in question. Shelley's method of writing the *Lament* may be altogether different from Swinburne's or Byron's methods, different also from Shelley's own method in writing the *Ode to the West Wind*. Accordingly it will be necessary to decipher, study, and interpret as large a body of such materials as is possible. But such work will not be without its compensations, as it may throw light on neighboring fields of inquiry. Should a study of two poets disclose differences in their methods of construction corresponding to the differences in the character of their poetic productions, an experimental basis would be found for a good deal in aesthetics which at present rests only on theory. Of necessity, an investigation of this sort will have to be based on modern poetry alone, there being none of Virgil's or Dante's scratched up pages in existence. But that in

itself will be no objection, if only a wide enough selection of first drafts from the great modern poets be available. If several genuine contemporary poets could somehow be induced to preserve their first drafts, without being aware that they are providing psychological material, much valuable information could be secured. Every successive interpretation will contribute to check up the experimental conclusions already reached and to establish them more firmly.

Even when all this is done, however, still one objection remains: what of the very most initial beginning of the poetic process: the so-called divine afflatus, the first breath of inspiration? That, I admit, cannot be reached by this method. This method is available from the first stroke of the pen: from that stroke on it is strictly experimental. But have we any reason whatever for believing that the continuity of the poet's creative process experiences a radical break precisely at the point when it begins to express itself on paper?

The limited time I have been able to devote to this problem has been spent largely in collecting, deciphering, and interpreting a few of the coveted first drafts. I have sedulously endeavored to avoid all speculation until an adequate supply of objectively established data could justify my proceeding to theorize. At present my supply is still meagre, but, while it does not warrant me in advancing any positive conclusions, it has abundantly vindicated my initial faith in this method as a means of studying, in genuine experimental fashion, the actual process of poetic construction. The present stage of my work gives me reason to hope that before very long I should be able to indicate, at least in broad outlines, the nature of the conclusions to which my inquiry has led me.

But I am becoming increasingly convinced that any generalizations reached by means of this method will be the more reliable the wider the field of poetic material which serves as their basis. This consideration has led me to overcome the natural reluctance of reporting on uncompleted work. My excuse for presenting this rough outline of efforts as yet unrewarded by positive results is that it may, perhaps, lead others, whose environment affords better opportunities for photographing or copying significant first drafts of genuine poetry, to interpret such poetic records with an aim similar to mine; and that, on the basis of several independent investigations of this sort, valid conclusions may be attained concerning the psychological description of the process of poetic construction.

THE EFFECT OF THE ATTITUDE OF THE SUBJECT UPON THE MEASURE OF SENSITIVITY

By SAMUEL W. FERNBERGER*

Some time ago, in an experimental study in lifted weights, the results of one subject showed that in a series of 1,200 judgments he had not judged a single pair as equal.[1] In such a series of results the thresholds in the directions of increase and decrease coincide; and hence the interval of uncertainty and the measure of sensitivity are zero. Woodworth[2] in a recent study remarks that theoretically this could happen and hence concludes that the interval of uncertainty is a poor measure of individual differences. As regards the first part of this statement, we agree. The interval of uncertainty should theoretically and does empirically reduce to zero. This is obvious inasmuch as the size of the interval of uncertainty is directly dependent upon the relative number of equality judgments which the subject may report in any given series. But the fact that this measure may reduce to zero is not a valid reason for believing that it is not a good test for individual differences. The thresholds that determine the interval of uncertainty are defined in terms of probabilities; and as such they are open to variation from a number of influences. Many of the objective factors that may cause such variation have been analysed from the total complex. For instance, we have standardized the psychophysical procedure so that the time and space errors may be eliminated. Woodworth believes that this reduction of the interval of uncertainty to zero, in an apparently normal series from the objective side, is due to a subjective factor. In our paper, mentioned above, we drew the same conclusion and stated that we believed that this was due to the subjective attitude of the subject inasmuch as he set for himself the *Aufgabe* of look-

* From the Psychological Laboratory of Clark University. I am indebted to Professors J. W. Baird and F. M. Urban for many helpful suggestions in the preparation of this paper.

[1] S. W. Fernberger, On the elimination of the two extreme intensities of the comparison stimuli in the method of constant stimuli. *Psychol. Rev.*, XXI, 1914, pp. 335-355.

[2] R. S. Woodworth, Professor Cattell's Psychophysical Contributions. *Arch. of Psychol.*, No. 30, 1914. 66f.

ing for a difference. But this introduction of a subjective factor does not invalidate the interval of uncertainty as a measure of individual differences. We must only note one other factor that must so far as possible be controlled in our experimental arrangement. It is of course true that since this is a subjective factor, it will be much more difficult to control than objective factors; but with trained subjects at least, introspections should reveal how nearly they have accepted the instructions of the experimenter. A measure of individual differences such as Woodworth apparently has in mind, would measure mere sensitiveness of the peripheral end-organ and not the sensitivity of the psychophysical organism with regard to our stimuli and our objective conditions.

Brown [3] has unwittingly shown most clearly the effect of the instructions upon the relative number of equality judgments. He strongly impressed upon his subject that she should be able to find a difference between each of his pairs of stimuli provided that she concentrated enough upon the judgment. Thus, by his instructions, he emphasised the attitude of looking for a difference; and the subject gave practically no equality judgments in a long series of liftings.

In order to test further our hypothesis that these variations were due to the attitude or *Einstellung* set up in subject by the *Aufgabe* or the acceptance of the instructions, we devised the following experiment in lifted weights. The usual series of seven pairs of weights were prepared, the standard weight of each pair being 100 grams, and the comparison weights 84, 88, 92, 96, 100, 104 and 108 grams. By means of a table provided with a revolving top we eliminated the space errors. The time errors were present in the first order but were kept constant by having the lifting controlled by the beats of a metronome.[4] The results were treated by the method of constant stimuli as developed by Urban. Fifty judgments upon each of our seven pairs of stimuli were recorded for each subject after he had been given a sufficiently long period of preliminary practice to mechanize the hand movements.

Fourteen subjects were employed, all of them graduate students in psychology at Clark University. None of these students knew this particular technique of lifting, before the

[3] Warner Brown, The judgment of difference, *Univ. of California Pub. in Psychol.*, I, No. 1, 1910, 1-71.

[4] For a detailed description of the type of stimuli employed, their arrangement upon the table, and the manner of lifting cf. S. W. Fernberger, On the relation of the methods of just perceptible differences and constant stimuli. *Psychol. Rev. Monographs*, XIV, No. 4 (Whole No. 61), 1913, 7-18.

experiment; and none of them was sufficiently well acquainted with the previous studies in psychophysics to be biased in the judgments. Furthermore, none of the subjects was informed of the problem which we were attacking. These subjects were divided into two groups of seven each. The stimuli were presented in a similar manner to the different subjects of these two groups and the conditions of the experiment remained as rigidly constant as possible, except for the instructions given the subjects at the beginning of the experiment.

The instructions for the technique of lifting and the like were similar for both groups. When we came in our discussion to describe the different categories of judgment to be employed, we here varied our instructions for the two groups. To Group I, we gave the normal instructions usually given to subjects for the method of constant stimuli: "You are to judge whether the second weight is heavier, equal or lighter than the first weight in each pair. There may be times when a doubtful judgment may occur, that is, when you are unable to decide whether the second weight in a given pair is lighter, equal or heavier than the first weight. In such a case announce your judgment as equal." Exactly similar instructions were given to Group II, except that we then added: "There has been more or less discussion in the literature of psychophysics as to the admission of the equality judgment. Some writers believe that it should be excluded. In my own experience, I find that the equality judgment does occur, both as actual subjective equality between the two stimuli of a pair, and also as doubtful judgments. I believe that you will find also that the equality judgment does occur in this series. Let me caution you, however, not to force any equality judgments; but do not hesitate to give such judgments if they do occur. Judge these stimuli honestly and to the best of your ability, but do not allow yourself to be prejudiced against giving them by any studies which you may have seen, which recommend that the equality judgment should be eliminated." We were exceedingly careful that the instructions should be given accurately to the different subjects in the two groups; and the subjects were requested not to discuss the experiment with any other students.

We believe that by means of these instructions we succeeded in giving different *Aufgaben* to our two groups of subjects, and as a result, different *Einstellungen* toward the problem. The usual instructions, such as we employed in the case of Group I, seem to give the subject the attitude of looking for a difference rather than of using equally his three categories

of judgment. This attitude may have given rise to the entire question in the literature of eliminating the equality judgment, because the subject uses the three categories differently. Working under the influence of his *Aufgabe,* he first searches for a difference; and when he fails in this, he then turns toward the equality judgment. On the other hand, by emphasising the equality judgment, as we did in our instructions to Group II, we believe that we made the three categories of more nearly equal value.

The effect of these different *Aufgaben* and the resultant attitudes toward the experiment, become evident when we examine the size of the intervals of uncertainty obtained for the two groups. These values for Groups I and II appear in Tables I and II respectively. The tables are similarly constructed. The subjects are indicated in the first columns; in the second columns are given the values of the interval of uncertainty $(S_2 - S_1)$ for each of the subjects. In the third columns are recorded the value of the measure of sensitivity $\left(\frac{S_2 - S_1}{2}\right)$. Finally in the last columns are to be found the values assumed by the point of subjective equality $\left(\frac{c_1 + c_2}{h_1 + h_2}\right)$ for the different subjects. In the bottom rows of the tables will be found the averages of the values in each of the columns.

When we compare the values of the interval of uncertainty for the different subjects, we find that those obtained from Group II,—with whom the equality category was emphasised in the instructions,—are very much larger than those from Group I,— who worked under normal instructions. Indeed, the largest individual value for this interval for Group I is smaller than the smallest value for Group II. On the other hand, the values obtained for Group I,—who worked under the normal instructions,—are quite similar to those obtained from other studies where a similar technique was employed.[5] Thus the intervals for Group II are considerably above the normal. The difference between the averages for the two groups is exceedingly large, being 3.504 grams. This is nearly 63 per cent. of the average value for Group I. Hence the interval of uncertainty for Group II is considerably more than half as large again as that for the first group. Obviously

[5] cf. F. M. Urban, *The Application of Statistical Methods to the Problems of Psychophysics,* Phila., 1908.
S. W. Fernberger, *ibid.*

the same relations hold for the measure of sensitivity since it is merely one-half of the interval of uncertainty. On the other hand, the averages of the points of subjective equality for the two groups are exceedingly similar, being 95.77 grams for Group I and 96.22 grams for Group II, a difference of only 0.45 grams. Such a variation is well within the limits of what one might expect in such an investigation. This means that although the relative number of equality judgments for the two groups varied considerably, still the relative number of heavier and lighter judgments showed little variation one with the other. Or in other words, in Group I the judgments which were not given as equal were divided between the heavier and lighter categories with approximately the same relative frequency as these two categories occurred for Group II.

It would seem that the exceedingly large variations in the size of the interval of uncertainty indicate that Group I had a higher sensitivity than Group II. But we do not believe that this is the case. One can not measure sensitivity in absolute terms; one can only say that a given sensitivity has been found to exist *under certain given experimental conditions.* Inasmuch as we are dealing with a total psychophysical organism and not merely with a sense-organ, it is, after all, not surprising that the attitude of the subject should have a profound effect upon this sensitivity. The above results indicate that this is true empirically. The investigation of such subjective factors is one of the main problems of the psychophysical methods. The similarity of the results in former studies indicates that for most subjects, similar instructions will arouse similar attitudes toward the experiment. Now and then a subject will set for himself a different *Aufgabe* than the one which the experimenter tries to have him accept. Usually this is because the subject desires to 'do well' and believes that the giving of equality judgments is an indication that he can not discriminate so accurately. Such a reaction is to be found in the subject described in our former study. But in such a case, the experimenter is able, quite readily, to ascertain this fact from the exceedingly small size of the interval of uncertainty itself. The experimenter should be able to ascertain the attitude and *Aufgabe* of the trained subject from the introspective reports. But for the untrained subject—that is, if the methods be applied for diagnostic or anthropometric purposes—the methods must be used with greater caution and with a realization of the fact that here is

a subjective factor which may cause exceedingly large variations in the measure of the sensitivity of the subjects.

TABLE I

Subjects	Interval of Uncertainty	Measure of Sensitivity	Point of Subjective Equality
I	6.28	3.14	94.72
II	5.80	2.90	95.22
III	6.74	3.37	98.23
IV	4.91	2.45	92.98
V	7.08	3.54	96.96
VI	3.64	1.82	95.54
VII	4.50	2.25	96.75
Average.....	5.56	2.78	95.77

TABLE II

Subjects	Interval of Uncertainty	Measure of Sensitivity	Point of Subjective Equality
I	7.32	3.66	97.86
II	7.72	3.86	97.02
III	10.70	5.35	95.00
IV	8.79	4.40	95.87
V	9.22	4.61	96.42
VI	9.36	4.68	94.38
VII	10.37	5.18	96.96
Average.....	9.07	4.53	96.22

THE ASSOCIATION METHOD IN ITS RELATION TO THE COMPLEX AND COMPLEX INDICATORS

By SAMUEL C. KOHS, A. M.,
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FOOTNOTE.—The writer wishes to express his earnest appreciation of the valuable aid, suggestions, inspiration so frequently, willingly, gladly offered by his leader and guide, G. Stanley Hall, before, during, and even after this article was in its formative stages.

A. Introduction

A large number of present-day tendencies in psychology seem to be directed toward individual differentiation and subjective analysis. The farther we advance into these realms of investigation, the more are we overpowered by the burdens of our ignorance. Nevertheless, the contributions made to psychology in the last decade or two, show conclusively that we are successfully wedging our way into the dark, hidden recesses of our "Denkfabrik." Our senses are as yet too dull, too undeveloped, too inaccurate to appreciate the finer, inner workings of our psyche. That some day the science will be in a position to explain a large number if not all of the mental mechanisms is the confident belief of many. At present, we must be content with objective results, verified and supplemented by introspection.

B. Some Psychological Concepts

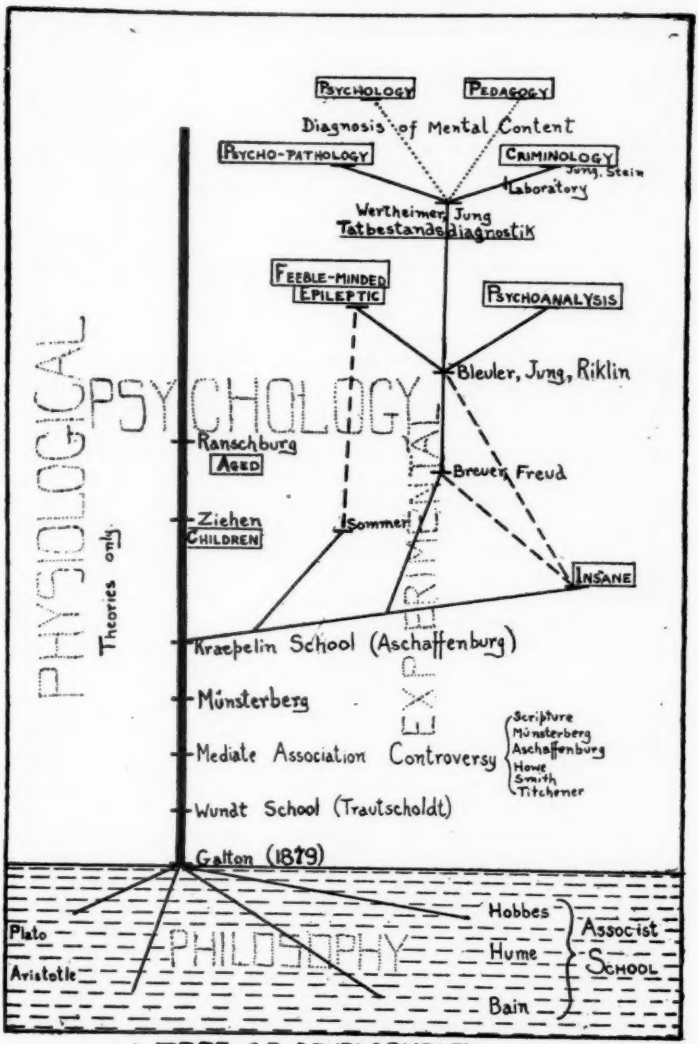
The process of association is, from the synthetic point of view, the keystone of our mental life. It would be folly to maintain at this date, with Hobbes, Hume, Bain and the rest, that the phenomenon of association is the *all* of consciousness. We must admit, however, that it is one of the basic factors making for normal mental activity. Perception, thought, action cease when the association process is interfered with. The laws of memory, of habit, of thought, are but a restatement of the laws of association.

Besides frequency, vividness, recency, primacy, intensity, and emotional congruity, there are a large number of factors which tend to influence the relations between ideas. (It is these *relations*, by the way, which we have in mind when we speak of "association.") And every attempt to arbitrarily classify these connections into different categories, outer, inner, egocentric, mediate and so on, has failed in many respects. This condition has largely been due to one or more of these reasons: (1) the tendency of classifications to be artificial; (2) their tendency to be superficial; (3) they are not based on introspection, and as a result they are objective instead of being subjective; (4) the separate categories are not sufficiently exclusive; (5) the experimenter may not correctly interpret the response; (6) the presence of mental imagery aroused by the stimulus is but poorly expressed by a single-word response; (7) our associative procedure is probably too complicated to bear a minute analysis, as yet.

It is not surprising, then, to find Cordes criticizing the early experimenters in this field for making such a simple process of the associative mechanism. He attempts an improvement by dividing it into two divisions, naming one the " A "-phenomenon, which includes the reception of the stimulus and the character and state of consciousness at the time, and the other, the " B "-phenomenon, which includes the response and the mental state at that time. This analysis is but a mere beginning. We have not advanced very far beyond it since. It is interesting to note that Jung and Riklin, mindful of Cordes' conclusions, designate their experiments as " verbal reactions to stimuli."

According to Hobbes, the natural state of one's ideas is uncontrolled, desires and wishes directing the train of thought. Where will and desire are more or less destroyed, as in dementia, the flow of ideas remains uncontrolled. It is recognized now, however, that ideas come to consciousness not only independently of our will, but oftentimes even against it. We see the extreme form of this in melancholia and in the obsession psychoses. For Wundt, this directing is done by apperception. He differentiates between perception and apperception as follows: In perception the idea is present in the field or " Blickfeld " of consciousness; in apperception, the idea is in the center or " Blickpunkt " of consciousness. Ziehen maintains that Wundt drives this theory of apperception a little too far, making the process superior even to that of association. The assumption that apperception is a sort of special selective faculty located somewhere in the frontal lobes of the brain, makes one justly wonder whether Wundt is not here being unconsciously influenced by the old faculty psychology. Sutherland emphasizes the fact that as yet we know too little of apperception to undertake a study of its influence on one's train of ideas.

The neurologic mechanism of association is still a matter of speculation. But whether it be conceived as neural habit, least resistance, " drainage," or what not, these phenomena *are* apparent: the process of association remains constant in its manifestations, it obeys certain laws, it can be studied experimentally, and the results may be utilized for educational and psychotherapeutic purposes. The nervous system receives and stores impressions. It consequently presents the paradox of being unchanged in what it has already acquired, and of constantly changing through what it is continually receiving. We must also recognize that the unconscious is the great storehouse of impressions.



A TREE OF DEVELOPMENT
to illustrate the progress of association experiments

C. Significance of Association Phenomena

Keeping this in mind, let us ask what is the significance of association phenomena. To Bleuler, "The process of association epitomizes the complete psyche, the past as well as the future with all of its experiences and aspirations. It is an index to all mental phenomena, which we only need to decipher in order to obtain a complete knowledge of man."

Semon has given to science the "mnemic" theory, the main thesis of which had long before been held by such men as Claude Bernard, Haekel, Orr, Cope, Nägeli, Hertwig, Hering, Samuel Butler, and which is now being so ably supported by Hering, Semon and Francis Darwin, among others. It postulates, first, the possibility of stimuli leaving traces or engrams in an organism; and secondly, a dormant condition of engramatic characters in both soma and germ-plasm, which become active as the individual develops. According to this theory the growth of the chick from the egg is merely an act of memory long imprinted upon the animal mechanism. With the conjugation of the germ cells, memory begins its marvelous process of regular, unchangeable activity. Each completed act serves as a stimulus for the next one. What appears a rather simple structure, is literally charged with vast complexes of memories. The greater the charge, of course, the higher up is the organism in the phyletic series. Ribot even goes so far as to say that "memory is essentially a biological phenomenon and only accidentally a psychological one."

Much as one wishes to adhere to Weismannian principles, it is very difficult to conceive that progress leaves no transmissable trace or "engram" upon the individual. The modification, no doubt, is most microscopic, most minute. But without postulating its existence, how can we explain many of the facts of heredity?

Man's progress up the evolutionary ladder has not been a smooth or regular one. To reach his present state of development, he has been compelled to pass through severe, oftimes cruel, sharp struggles in order to obtain food, warmth, shelter, protection, for the purpose of preserving the life and vigor of both individual and species. The slow convulsions of nature forced him into an ever-constant adaptation to climate and environment. He was driven into perpetual experimentation, with its attendant sore trials, harshly-reacting errors, as well as triumphant successes and happy achievements. The joys and fears, the pleasures and pains of the

intense effort upward must have left their traces somewhere in the organism.

Like the cells of the developing chick, we are often impelled to acts, to thoughts, by a something in us which is inexplicable, undefinable. Schopenhauer, in his essay "On Virtue," says the following: "The lover is deluded in thinking that he aims at his own happiness. The will to live is forcing him, for nature's own purposes, to aim at a certain typical beauty, which has its end in the perfection of the offspring. The more perfectly two individuals are adapted to each other, the stronger will be their mutual passion. Nature is striving for a better realization of the type, and to attain its ends must implant a certain illusion in the individual. That which is good only for the species appears to him as good for himself. This illusion is instinct. The individual is but a helpless tool carrying out blindly the designs of nature." Le Bon, in his "Psychology of the Crowd," says, "behind the avowed causes of our acts there undoubtedly lie secret causes that we do not avow, but behind these secret causes there are many others more secret still, which we ourselves ignore. The greater part of our actions are the result of hidden motives which escape our observation." Swoboda and Fliess have demonstrated the theory of periodicity in human activity, a phenomenon quite independent of volition.

Just as the human frame is an "old curiosity shop" full of unnecessary antiques, so also is the human psyche a vast storehouse for the stirring, epoch-making events of phylogenesis. Since refined surgical and histological methods reveal a mass of rudimentary and vestigeal organs, may we not also expect that refined psychological procedure will reveal as much, if not much more, on the mental side? Already psychoanalysis has made an excellent beginning.

Leaving these purely theoretical and hypothetical considerations aside, we will now enter the problem proper, with a short review of the experiments in association for purposes of better orientation.

D. Historical Survey

The phenomenon of association had been observed by Plato and Aristotle. They classified the relations between ideas into logical categories. The study and discussion of this whole problem was continued in the realms of philosophy culminating in the extreme views of the associationist school. The experimental work began with Galton in 1879. His method was simple and crude. He, nevertheless, obtained very valu-

able results. In 1880, Wundt took the problem into his laboratory and in 1883, Trautscholdt published an extended article on the subject. In 1885 followed Wahle. In 1889, Münsterberg published his "Beiträge," giving an account of association in adults. Three years later began the controversy on mediate association, Scripture, Aschaffenburg, Münsterberg and Wundt being the participants; later Cordes, Howe, W. G. Smith and Titchener were added.

It is natural to expect that the first movements should be concerned with the *mechanism* of association, the process being considered detached from the individual. Rittershaus, however, is unrelenting in his criticism. He distinctly emphasizes the fact that it is altogether impossible for us to possess a purely abstract psychology of association before we possess a concrete, individualistic one. He, like many other critics, takes these experimenters too harshly to task failing to realize that the whole problem was passing through a normal, wholesome evolution.

Beginning with Kraepelin in 1896, we notice a deviation from past methods, first as regards the aims of the experiments, and secondly, as regards classification. Kraepelin was the first to outline an extensive program for the investigation of neuropathic and psychopathic conditions. He studied the effects of practice and drugs on association. Of his students, Bethmann investigated the relation of mental work to changes in association,—Aschaffenburg, the effects of fatigue and exhaustion,—Weygandt, the effects of hunger. Aschaffenburg made some radical changes in the hard and fast, iron-bound classification of the Wundtians. He readjusted it to permit the inclusion of marked deviations due to some abnormality.

In France, Ribot was the first to emphasize the significance of individual differences and to differentiate types; Bourdon was mostly concerned with classification, and Dugas did work similar to that of Ribot. In America, Cattell, Calkins and Jastrow were the chief workers in this field. Eighteen hundred and ninety-eight saw the appearance of Ziehen's masterful contribution to the association of ideas in children. His predecessors in this field were many, but Ziehen was the first to make a thorough, scientific study of the subject. He also attacked the logical method of classification because it neglected content and was only interested in form. Unfortunately, it was hard for Ziehen to break away wholly from these preconceptions, and the results obtained from adults influenced his methods, as well as the interpretation of his data, too greatly.

At about this time appeared Ranschburg's article on association in the aged. In 1899 appeared Sommer's "Lehrbuch." By 1906, the Zürich School was already well organized and it began its epoch-making series of contributions headed principally by Jung and Riklin. From these studies dates the work which will be more intensively discussed later, and which makes apparent the enormous significance of the phenomena of associated ideas. Jung and Riklin opened the doors of the subconscious. Immediately the complex was seen in its true significance. At present, this knowledge is being utilized in three directions, first, to determine the relation of the complex to aetiology in mental disorders; second, to determine its relation to mental content; third, to determine its relation to impulses, ambition, ideals, character.

For bibliographies, the following may be consulted since they cover a large part of the literature (see bibliography):

Claparède. L'association des idées. 1903.

Ley and Menzerath. L'étude expérimentale de l'association des idées. 1911.

Rittershaus. Die Komplexforschung. 1910.

Lipmann. Die Spuren interessebetonter Erlebnisse und ihre Symptome. 1911.

E. Constellation and Complex

I. *Definition*

Coming to our problem more specifically, let us define our terms. The literature is very vague in the use of the words "constellation" and "complex." All writers, with but few exceptions, have a tendency to handle them very loosely, carelessly and ambiguously. For that reason, a definition which is accurate and at the same time in accord with common usage is practically impossible. I will make an attempt, however.

Ziehen was the first to use "constellation" in its present significance. To him "constellation" was an associative grouping of various ideas around a central idea. Thus,—assuming *a* to be a central idea, there may be associated with it in consciousness, *b, c. d. e.* etc. At one moment the recall of *a* may recall *b;* at another, *c* may be recalled; and so on. Jung and Riklin modify this definition by adding that the experience creating a constellation of ideas must have been individual, subjective, have occurred within recent time and must possess a distinct feeling-tone. As it is used to-day, "constellation" means an associative arrangement of specific mental data. This mental data may consist of sensations, percep-

tions, ideas, impulses, desires, feelings, and so on. Any of these, and all of these in various combinations, are the units which compose the constellation. The mental data must not necessarily be pure ideas, as is held by some. In analyzing constellations, it will be found that each is composed of a different mosaic of mental elements, differing in character, significance, intensity and meaning. Also, since sensations, perceptions, memories, always possess affective accompaniments, all constellations, which are only hierarchies of these mental elements, possess some *feeling* tone. In many instances, it is so slight as to remain unnoticed, and in others it is so intense as to force the constellation to become transformed into the complex. The difference between a constellation and a complex is a difference of intensity in affective-tone. Education, environment, home influences, age, sex, race, religion, certain hereditary predispositions, are among the most important factors determining the type, number, and trend of one's constellations.

As has already been indicated, the complex is merely a constellation possessing a more intense affective-toning. Some writers maintain that this feeling element must be one of pain. With this position I disagree, since pain is only a small portion of the enormous field of affection. The constellation becomes a complex when the affective content changes from feeling to emotion. It must be particularly emphasized that the existence of complexes in consciousness or in the unconscious, is neither pathogenic nor pathognomonic. The phenomenon is perfectly normal. We all possess complexes. We are aided by some, we have to contend with others, still others are sublimated and we are better off as a result. It is the neurotic who suffers.[1] Any complex coming into conflict with ethical or aesthetic principles may, after a struggle for dominance, be repressed (verdrängt) into the unconscious where it continues its efforts to reach the " Blickpunkt," the center, of consciousness.[2] With neurotics these complexes increase, unify and exist apart

[1] And in this respect, the recent psychoanalyses of psychopaths and criminals, on the one hand, and geniuses, artists, poets, on the other, reveal that the operation of the complex in both types is very much alike. Consequently, our future treatment of the social deviate both before and after committing an offense must take this fact into consideration.

[2] Freud gives some interesting explanations in this connection with regard to forgetting generally, as well as infantile amnesia and covermemories ("Deckerinnerungen"). The censor, an active, mental principle similar to Wundt's apperception, selects and rejects ideas as they come to consciousness.

from the primary personality. In this manner, one or more secondary entities or personalities may be created which live a life apart from the primary one. The complex thus obtains expression. With normal people the complex often obtains externalization through symbolism, displacement, conversion, transference, and through the channels of literature, art, humor, dreams. For further elucidation of these, and other phenomena, the reader is referred to the psychanalytic literature.[3] We are all, in a slight manner, however, examples of split-off personalties. This fact becomes clearer as we note a man's intellectual advance with age, the process of specialization becoming more and more apparent. All of us are a bundle of characters, of selves, each very different from the other, and each in varying stages of development. The individual at a baseball game is apparently totally unlike the one delivering a lecture on metaphysics; he is totally unlike the one leading a "gang" of boys into the open country; very different from the one standing judge over the seriousness of his moral transgressions; and totally unlike the one confessing deep and earnest affection for a pretty representative of the weaker sex. Yet all of the metamorphoses of self are due to changes of the predominating mass of complexes and constellations. These diverse personalities are normal manifestations, all being moulded into an harmonious unit. Synthesis is the keynote of mental hygiene. Where complexes have been repressed, and are split off or dissociated, there one is certain to find definite psychopathologic conditions.

The following are some conclusions relative to the emotional content of the complex by experimenters in this field: Birnbaum believes that the affective-toning possessed by a complex changes with time. According to Burr and Geissler, most of the normal, every-day complexes, and there are many of them, are not marked by very strong feelings. Jung and Riklin observed that during distraction the number of complexes discoverable in a given subject was greatly reduced. They also found, and to this Sutherland takes exception, that complexes do not necessarily have to be apparent to the sub-

[3] And here, perhaps, a word might be said concerning Freudianism. Many of the Freudian postulates cannot as yet be accepted in their entirety by the critical mind, as explanations of some existing conditions. None the less, there is a good deal which is valuable in the analyses, but one must be discriminating. The attempt to reduce so much of human activity and defectiveness to a sexual basis (in its broadest sense), is bound to fail. It is generally known and recognized that the predominating forces of life are not *all* exclusively libidinous.

ject, for the experimenter to be certain of their existence. They usually remain unnoticed until the association data are properly evaluated. According to Jung and Riklin's findings, confirmed by Rittershaus, most of the complexes are of an erotic, libidinous nature, thus emphasizing their great rôle in human behavior. Gallus stresses the fact that sometimes complexes are uncovered where one would least expect to find them, and at other times, where one is most certain of their presence, none exist.

II. *The Unconscious*

The complex and the unconscious are of great significance for normal psychology as well as for psychopathology. Investigations of hysteria, dementia præcox, paranoia, have already revealed a mass of data concerning the mechanism of the complex. All neuroses, according to the Freudians, are based on definite complexes. Normal psychology is now ready to take the path marked out by these pioneer workers in the field of mental disorders. The phenomena of forgetting, moods, character, likes and dislikes, ambitions, mental and physical ability, habits, the development of special aptitudes, all stand in close and intimate relationship to the complex and the constellation.

Probably the most important deduction one can make from "Komplexlehre," is that: *The moment a complex is created, it becomes a potent dynamic unit.*

F. The Association Methods

We now come to a consideration of the various procedures employed in detecting the existence of constellations and complexes. My thesis will include only the so-called free-association methods. In reality there is no "free" association. The relations between ideas are not accidental, but predetermined, and various factors influencing the appearance of an "Einstellung" will also influence the train of thought.

The aim of the association methods herein described is mainly to indicate the existence of complexes, or the possession of knowledge of a certain type (crime, or "Tatbestand" [constellation of facts]). Their application can be made to cover a much wider field, and may perhaps some day aid in the solution of the problem of higher mental tests for the Binet scale. The fundamental principles underlying the methods are as follows:

(1) An experience leaves some sort of trace in the psyche. Ideas are linked up which were not previously related, or the bonds which did previously exist are greatly strengthened.

(2) Relations between ideas can be proven to exist by the association method.

(3) By means of a properly arranged experiment upon two individuals, one possessing a specific constellation and the other not, one may determine fairly safely (using the response, qualitative, quantitative and physiological, as a criterion) which of the two possesses the specific constellation.[4]

I The Association Series

(1) *The Series Proper*

(a) *Number of Words*

Although there is a difference of opinion as to the number of words composing the series, it is generally held that 100 is the "happy" medium. According to Ley and Menzerath, the Jung series of 100 or 200 words is entirely too long. They favor one ranging from twenty to fifty words. Aschaffenburg points out that where 200 words are used as stimuli, the conditions under which the first twenty-five are reacted to, cannot be the same as those for the last twenty-five. Comparisons, consequently, may give entirely false results. At the other extreme is Kramer who maintains that the 100-word series is too small. It must be kept in mind, however, that fatigue may easily set in, and that the subject's attention may begin to be removed from the main purpose of the experiment. Lipmann states that 100 words should be the smallest number employed, and actually favors a longer series, since length finally destroys dissimulation. The more a person has reacted, the more will his mode of reaction become mechanized and the more independent will it become of volition. Repression and inhibition being reduced to a minimum, the complex or constellation can consequently be more easily reached. He believes that the larger the series, up to a certain point, the better the results. But a good deal depends on the purpose of the experiment, the mental type of the subject, the speed of the experimenter, general conditions and circumstances, for all of which allowances must be made. As to the time, Ziehen and Sommer never permitted their experiments to run over twenty minutes. It was usually between ten and fifteen.

[4] The distinction between an association test and a psychanalysis is this,—the association test establishes or confirms the existence of relations between ideas. It stops there. The psychanalytic method goes farther, and attempts to explain or interpret these relations by a closer, more intensive questioning, and its final aim is catharsis, "chimney-sweeping." The psychanalytic concept, however, is broadening out to mean more than what I have indicated.

Woodworth and Wells state that it requires from ten to twenty-five minutes to give the K. R. series of 100 words. Jung sets no limit as to time, but if fatigue is observed at the end of the first hundred words, the second series of 100 are reserved for another day. This has never been necessary with educated subjects. In conclusion, Löffler suggests that the association series ought to be different for every individual.

(b) *Character and Arrangement of the Words Chosen.*

The association series ought to be composed of relevant and irrelevant stimulus words, by relevant words meaning those related to a complex, and by irrelevant, words unrelated to it. Only to the first type is the subject expected to react suspiciously. The relevant or significant words are assumed to be irrelevant or insignificant to controls. Of course, in actuality, this is never entirely possible. Words of double meaning ought also to be included. Lipmann summarizes the necessary requirements of relevant stimuli by saying that they must be such as not to touch complexes possessed generally, they must not be unusual, difficult to understand, exceptional, they must not be easily distinguishable from the irrelevant either in the number of syllables or in grammatical form. Such procedure as that of Van der Hoeven, two irrelevant words being placed after each relevant one, is not scientifically advisable. There ought to be no regular array of significant and insignificant stimuli. Lipmann adds that the series should be so arranged that the subject will be surprised when confronted by a complex stimulus. He, consequently, advises the irrelevancy of the first ten words in order to mechanize the mode of reaction. Löffler and Lipmann also suggest arranging the words so that before a significant stimulus is reached an "Einstellung" of such a character will have been created that a complex-reaction will be greatly facilitated. Lipmann advises the following order of irrelevant and relevant words in the series: (r = relevant; i = irrelevant; s r = strong relevant)—ten i—four r—ten i —six r—eight i—one s r—six i—six r—fifteen i—one s r— ten i—eight r—eight i—seven r. (Total, sixty-seven i and thirty-three r.) Rittershaus is very much opposed to this arbitrary schematization, stating that no experimenter is able to formulate a series of relevant and irrelevant stimuli since no one but the subject can determine their character, and then only by means of his responses. In his experiment Schnitzler used twenty critical words which were as gross as possible (forceps, blood, etc.). According to other investigators, this greatly militated against the accuracy of his results. Thus

Löffler and Rittershaus maintain that gross, coarse stimuli ought not be utilized in searching out a painful spot. For, just as the physician is careful of his movements, tender in his touch during a diagnosis, so also must be the explorations of the psychologist, who is seeking for complexes in the innermost reaches of the psyche. With regard to critical stimuli, no set list can be given which might be employed by all. It must be remembered that conditions, subjects and experimenters vary greatly. However, Jung found that these words, among others, usually gave long reaction times: needle, hope, strange, false, heart, pyramid, strike, threaten, remember, ripe, to woo, fern, hair, nauseate, dream, paper, book, harm, softly, caress, family, consciousness, freedom, faith, violence, wonder. According to Wells, using the Kent-Rosanoff series (twenty-five cases), the ten words giving the shortest reaction times were: bitter, ocean, white, dark, yellow, swift, thirsty, sour, stove, scissors; and the ten words of longest reaction time were: square, command, anger, religion, moon, slow, health, justice, stomach, wish. Words to which some of the men (physicians) failed to respond were: intend, never, interest; and women (nurses):—disgrace, betray, expect, information, cravat, magnet, diagram.

(c) *Trial Series.*

It is advisable to give each subject a short explanation of the method to be pursued with short, simple, definite directions for reacting. A trial series of insignificant material consisting of ten to twenty words ought to be employed mainly for the purpose of making the directions and information concrete, and permitting the subject to become better oriented to the problem. By means of this trial series, the experimenter can obtain a better insight into the mental type of his subject. Kramer and Stern used a trial series of 100 words, but this length is neither necessary nor profitable.

(2) *Presentation of the Stimulus*

(a) *Mode of Presentation.*

There are two forms in which the stimuli may be presented. First, in auditory fashion, either by the experimenter, pronouncing them,[5] or as Lipmann suggests, by means of a phono-

[5] As yet, we know but little of the mental processes which are brought into activity in the subject by the manner and tone in which the stimulus is given. Cordes earlier, and Levy-Suhl later, both emphasized this point.

graph. (The latter, Rittershaus calls " scientific fool's play.") The stimuli may also be presented visually by using the tachistoscope. But Rittershaus advises against the use of this extra apparatus, since it only complicates the procedure and may disturb the results. Besides,—some subjects cannot read very easily, some may have some apperceptive difficulty, others may feel compelled to translate the seen word into auditory, motor, or voco-motor terms in order to grasp its meaning. In the last case especially, the effort may result in an audible pronouncing of the stimulus which, by some careless experimenter, might be interpreted as a mechanical repetition and diagnostic of a complex. The tachistoscope, nevertheless, has the advantage of being independent of any personal influence of the experimenter, the stimuli remain constant, which factor also favors the use of the phonograph for auditory stimuli, and pictures, colors, etc., as well as words, may be presented. Lipmann indicates the value of the tachistoscope for the phenomenon of " Verlesen," of misreading,—e. g., a person guilty of murder, instead of seeing the stimulus "Mond"—will see it as "Mord." The same holds true of the phonograph (Verhören), the word Olch is heard as Dolch (dagger) by the murderer, as Strolch (tramp) by the tramp, and as Molch (salamander) by the innocent. Cordes maintains that visual stimuli are stronger and better to work with than those of an auditory type, and that ideas come more spontaneously when the word is seen than when it is heard. As we have remarked above, this latter depends greatly upon the individual. He goes on to state that we are more accustomed to *seeing* isolated words than to *hearing* them, and that the *amount* of impression remains constant with visual stimuli, and cannot remain constant with stimuli of the auditory type. Ziehen, in studying the associations of children in the fields of color, space, number and time, utilized various methods of presentation.

In the older experiments, where words were presented visually, the subject was seated in a dark chamber, entirely soundproof. Pictures, symbols, colors, colored letters or words, single letters, nonsense-syllables, were presented by means of an exposure apparatus. This procedure is not much in vogue now, although Wundt prefers it to others.

On the whole, the best procedure is to have the experimenter pronounce the words himself, aiming, at the same time, to keep conditions as constant as possible. Lipmann suggests that the tempo ought not be too slow. The next stimulus should be given as soon after the response as pos-

sible. Thus the constellation is kept intact and no opportunity is given the subject to prepare a response. Aschaffenburg obtained, on the average, 200 associations in forty minutes or five associations per minute. In other words, in about every twelve seconds the whole process of presenting the stimulus, recording the response and holding a protocol was complete. Cordes states that this time is too short. Other authors give no data. Although it seems advisable to standardize the time, yet subjects and experimenters present such wide variations in rate of activity, that it would be almost impossible to strictly adhere to any set time without injuring the experiment. If any additional apparatus is used, such as a galvanometer, a pneumograph, automatograph, etc., more time must be allowed. This has its disadvantages, of course. Lipmann also states that the rendition of complex-stimuli ought not be especially emphasized in tone, in pause, or accent, no changes ought be noticeable in gesture or facial expression of the experimenter.

(b) *Instructions*

The method pursued in the association experiments is as follows: The experimenter gives the stimulus word and the subject is asked to respond with the first idea that occurs to him.[6] This "Aufgabe" may be put in various forms—"answer as quickly as possible with the first word that comes to your mind."—or "with the first thing this word makes you think of."—(In German,—"zu antworten mit das erste Wort das klar zum Bewusstsein kommt"—or "mit dem nächst einfallenden Wort zu antworten.") That the response will be but a small portion of a complicated association-complex is self-evident. Nevertheless, valuable results may be obtained, despite this handicap. Wertheimer and Klein have shown that only a slight stimulus is necessary to bring to light a whole crime-complex. Schnitzler, on the other hand, altogether denies the possibility of arousing a single association of a definite kind by means of a single stimulus word.

The procedure in which idea *a* calls up *b*, *m* calls up *n*, *g* calls up *h*, is called the reaction method. This differs from the *serial* method in which when *a* is given, *b* is associated.

[6] In reality, this procedure is only a simplification of the one usually adhered to in obtaining information, namely, questions are asked and the subject or patient is required to answer them to the best of his knowledge and ability. On the basis of this material, its amount and character, one is often able to pass a fairly safe judgment.

Then follows *c* in association with *b*, then *d* in association with *c*, and so on (a→b→c→d [C. S. Meyer]). Only the first type is being considered in this paper.

Sutherland found that a slight variation in stating the directions produced no observable difference in the response. Ziehen, working with children, sometimes repeated directions in order to hurry them on. This fact was always noted on the record sheet. He found no difference in results when the stimulus was given in a soft or a loud tone of voice. It would be much more advisable to keep *all* conditions as constant as possible *all* the time. In many experiments such as those of Kramer and Stern and of Rittershaus, it was found advisable to have one person give the association-series and note the response, while the other recorded the time.

(3) *Response*

To quote Wells, "In spite of all instructions to the subject about the 'very *first* word that comes into your mind,' etc., and the best coöperativeness, it is naïve to suppose that we get this response from the ordinary subject save in a comparatively small number of cases." Aschaffenburg also makes the observation that after the stimulus word is given, a large number of ideas may suddenly come into the conscious field of the subject. Usually, one is more dominant than the rest and thus finds expression. Trautscholdt and Wertheimer indicate that the reaction to the stimulus may come to consciousness first in terms of sensory, motor or kinaesthetic imagery, also as moods and feelings. From introspective accounts, the latter found that sometimes the stimulus word, as such, comes into consciousness. Other times it was a visual image of an article in the room, of which the complex-arousing word was a part. All imagery differed in intensity, clearness, and duration. Sometimes a peculiar awareness or attitude (Bewusstseinslage") was present, there was a consciousness of *seeking* something, of trying to remember, *e. g.*, (to quote from the introspections) "That is a word (content) which I have but shortly seen," "that is somewhat critical," "that is betraying," "I ought not to express this." Wertheimer also observed that the appearance of a reaction word was always present with a strong impulse to express it. The following are some of the reports: "The complex-reaction burst out suddenly without permitting me sufficient time to judge whether I wanted to say the word or not." "The desire not to express a betraying word was very strong, nevertheless the content was of such

great strength that it forced itself through these barriers." "I could do nothing else; I knew perfectly well that I ought not to say the word, but I could do nothing else, the pressure was too great." "I wanted to substitute another word, but I uttered the word which I did not want to." "It took me unawares, I could not stop it." "The complex-word was present with such power, that it suppressed any emerging irrelevant word." "I could think of nothing else." In the cases where reaction-words were successfully repressed, a peculiar condition, called a "mental vacuum" was produced. These are some of the reports: "There was a complete emptying of conscious material." "It feels as if everything had disappeared from consciousness, an absolute lack of ideas." Very often this condition of mental vacuum was accompanied by a distinct feeling-tone, described as "uncomfortable," "painful," "a feeling of tension, suspense," "a feeling of perplexity." In some cases it even took the form of "a feeling of fear, no word will come into consciousness, time is quickly passing, perhaps a complex-word will appear." This condition ceased when a word was finally spoken or when an active "search" was instituted for an appropriate response. In this connection, it might be mentioned that Schnitzler observed a number of cases where an irrelevant response followed quickly after the complex-stimulus was given. In such cases, the real significance of the stimulus word became apparent to the subject only after the irrelevant reaction had already been expressed.

The recorder is expected to note everything possible—the response, the reaction time, the behavior, all movements and expressions. The significance of this data will be discussed later under complex-symptoms.

(4) *Miscellaneous*

(a) *Sex and Personality of the Experimenter*

Both Pfenninger and Morawitz indicate that the psychosexual "Einstellung" of a subject must have some effect on the response and reaction time. This "Einstellung" naturally, varies with the sex of the experimenter. Sutherland also maintains that the type of the investigator (personality, voice, sex, social position) and the type of the person examined (sex, social position) both affect the results before, during and even after the experiment is complete, when an attempt is made to interpret the data. Aptekmann (Zürich laboratory) may be said to be the first to make a direct study of this

problem. Her procedure, however, is open to grave criticism. Her subjects were six educated men and six educated women. Jung and Aptekmann each served as experimenter and both their results were compared. She concludes as follows: (1) The *male* experimenter produced greater affective changes in the subject. (2) Where the experimenter and subject were of the *same* sex, more *social* complexes appeared; where they were of the *opposite* sex, more *erotic* complexes appeared. More data are sorely needed.

(b) *Factors Influencing Associative Relations*

(1) Age.—Ziehen found that children respond with *particular* ideas, whereas about eighty per cent. of adult responses are by means of *general* ideas,—again confirming the long-established fact that children deal with particulars. The reaction time with children is longer than with adults. Children give about two per cent. verbal or word associations. With adults this percentage is much increased. Ziehen and Meumann found that children between six and thirteen who gave a larger proportion of particular ideas, were the brighter. Ranschburg found that adults gave 11.8 per cent. more inner associations than younger people. Jung and Riklin found the same to be true in their investigations. In other words, the older a person, the greater the probability that words will be associated by content, by inner significance, and not by mere sound, or any other objective relation. The first type of response (inner association) results in a longer reaction time. This relative difference does not change with age.

(2) Sex.—Jung states that the method is as yet not sufficiently developed to show the finer sex differences. Still he and others did obtain some very interesting data. Rittershaus has indicated that the larger portion of complexes belong to the sex sphere. The percentage is greater in women than in men. Wells observed that of the rather long reactions, the men gave eighteen, the women seventy-two. Haggerty and Kempf have pointed out that a large part of sex differences were due to attempts at suppression and substitution. Women show a shorter reaction time compared with men when there is *no* inhibition, and a longer time than men when inhibition is active. These results agree with Pfenninger's findings. Wells noticed that some women show marked deviations from the average of their sex. Sometimes, consequently, a careless statistical treatment of data may greatly falsify the facts. The statement, so often made by Jung, that women give longer reaction times, does not hold strictly. An examination of his

data makes Wells conclude that there are two types of women, (1) those whose responses conform to the average of their sex, these subjects giving a shorter reaction time than men, (2) those whose responses show great deviations. The two groups ought to be considered separately, especially when making generalizations in the matter of reaction time.

Jung and Riklin found that men give a larger proportion of egocentric reactions. Educated men and educated women differ only slightly in their responses. Uneducated men show a much lower type of reaction than uneducated women, this difference being due very largely to man's meagreness of affectivity and subjectivity. This, of course, does not hold for educated men. From these results, one is naturally led to believe that educated men possess more feministic characteristics than uneducated men. Which is perhaps additional confirmation to those who believe that woman is higher in evolutional development than man.

Kramer and Stern observed that, in revealing the existence of a complex through content, only *one* reaction was needed in the case of men. With women, on the other hand, the diagnosis is not as simple and requires a number of responses before judgment can be passed. H. Gross explains this phenomenon on the basis of woman's almost instinctive tendency to secrecy. A woman has more to hide than a man, *e. g.*, menstruation, pregnancy, her interest in her husband, etc. She must be more careful in her speech than man is. With the development of society, its customs and taboos, she has finally acquired a natural tendency to keep from revealing her innermost thoughts. Perhaps this is so, and woman's reputation for talkativeness may only be an Adlerian "compensation" for her "minderwertigkeit" in these other directions. Other experimental data, such as that of Jung, does not seem to bear this out.

A quantitative, but not qualitative, examination of attention by Jung and Riklin indicated that uneducated women are superior to educated men in this respect, due largely to the fact that the situation to the uneducated is new and strange; the experiment being more like a mental test, attention is consequently concentrated. The educated individual approaches the problem as an easy, simple one, and attention is not intensely concentrated.

(3) Race.—Aschaffenburg merely mentions the necessity of further research in this direction, but as yet I have found no work dealing directly with this phase of the problem.

(4) Family.—Jung and Riklin noticed resemblances in the reactions of members of the same family. Emma Fürst confirmed their findings.

Jung and Riklin, for example, cite this case:

Age	Inner	Outer	"Klang" or Sound	Egocentric
Mother over 50.....	75%	19%	0%	40%
Older daughter about 38....	56%	39%	1%	15%
Younger daughter about 35	35%	58%	5.5%	7%

This data, however, is liable to be a little misleading. One would suppose that when the younger daughter attains her mother's age, her reactions would be the same as those of the parent. This cannot be the case. For example, comparing the two sisters who differ in age by about three years, it is very, very questionable whether the younger sister will in three years give 56% of inner associations instead of 35%, an increase of 21%—or give only 1% of sound associations instead of 5.5%.

Besides concluding that relatives show a marked agreement in reaction type, Emma Fürst also adds that children tend to resemble the reaction type of the mother more than that of the father. There is a smaller difference between father and son, than between father and daughter,—and a smaller difference between mother and daughter, than between mother and son.

(5) Intelligence.—Rittershaus indicates that subjects coming from a lower level of intelligence are not accustomed to think in terms of single words or ideas, but in sentences. Believing that the experiment is a sort of intelligence test, they tend to say as much as they can in response to the stimulus.

The following is taken from Jung's data:

The reaction time of educated men—averages 1.3 seconds;
The reaction time of uneducated men—1.6 seconds.
The reaction time of educated women—averages 1.7 seconds;
The reaction time of uneducated women—2.2 seconds.
Average for the educated, 1.5—for uneducated, 1.9.

Jung's results also show, to one's surprise, that the uneducated give more inner associations in the following proportions,—43: 36%, and less outer associations,—53: 59%. Because of this greater proportion of the inner type, the uneducated give a longer reaction time.

Sommer and others have found that the feeble-minded, some of the insane and the epileptic show a striking poverty

of ideas and tend to give stereotyped responses. Among others, Sommer cites this case:

Male: dement and epileptic.
Out of forty-six reactions—
table was the response to 13 of the stimulus words.
bone " " " " 10 " " " "
house " " " " 3 " " " "
child " " " " 4 " " " "
and dog " " " " 3 " " " "
Some of the long reactions were—
Hand—bone—18 4-5 seconds.
Room—table—27 1-5 seconds.
Lung—lung—22 seconds.

Moravcsik states that those possessing strong mental balance answer with single words instead of with more than one word or with a sentence. Schnitzler warns that many uneducated and ignorant individuals very often may give reactions which appear suspicious without there being any actual basis for it.

(6) Occupation.—Aschaffenburg experimented on two groups of physicians, the first consisting of five, and the second of four, subjects. His results with the first group were as follows:

39 out of 100 reactions were common to two physicians.
16 out of 100 reactions were common to three.
4 out of 100 reactions were common to four.
2 out of 100 reactions were common to all five.

In the second group:

23 out of 100 reactions were common to two.
14 out of 100 reactions were common to three.
0 out of 100 reactions were common to all.

Jung and Riklin give stronger evidence in the following two cases. One is a teacher of natural history. In the first half of the experiment, 26% of his reactions were related to his school work. In the second half, the percentage was twenty-one. In the first half, the name of the school is repeated four times, and a word relating to a certain event which occurred there, twice. The second subject is a chemist. Nearly all of his constellations are related either to his laboratory work or to his love affair. Rittershaus found many complexes in his subjects which were related to their occupations or habits.

(7) Emotion.—Aschaffenburg observed that anger, similar to overwork, insufficient sleep, exhaustion, tends to increase the number of associations by assonance and rhyme. According to Ziehen, emotions greatly influence reaction time,—feelings of pleasure facilitate associations; feelings of pain inhibit

them. This is excellently exemplified in the mental disorders, —mania on the one hand and melancholia on the other. Jung found that the stronger the affective tone possessed by a stimulus word, the greater will be the attention which the subject concentrates upon it,—and in consequence, the number of inner associations will be increased. This process then is just the reverse of distraction.

It is unfortunate that aside from these general considerations, there is nothing else, bearing particularly on this subject, in the literature. Birnbaum in 1911 made a study of the influence of affective factors on association, yet one cannot but be convinced that had Birnbaum utilized all that his predecessors had contributed with regard to method and interpretation, much more valuable and significant results would have been obtained.

(8) Beliefs and Ideals.—Jung and Riklin found that these sometimes stood out very clearly because of their constant repetition in reply to stimulus words.

(9) Fatigue.[7]—Aschaffenburg's results may be summarized as follows (Sommer):

(a) Under the influence of exhaustion, the relationship between stimulus word and reaction word becomes looser and looser, and may be easily broken depending upon the intensity of the original attraction between the two ideas. In this condition, the language relationships predominate, the stimulus word is not perceived by content but by sound. (b) Exhaustion tends to increase the reaction time. This difference is only slight. (c) As exhaustion proceeds, reactions by assonance, rhyme, word-completing and supplementing, and speech reminiscence, increase more and more. (d) Exhaustion brings with it an easier impulse to react. No attempt is present to inhibit the reaction.

Jung and Sommer question whether all of the above phenomena are due always and wholly to exhaustion. Fatigue may serve as a reducer of inhibitions, in which case complexes may more easily be brought to light.

(10) Drugs.—(Alcohol, tea, coffee, etc.) In general, their effect is similar to that of exhaustion. It would be a most interesting problem to determine the effect of internal secretions upon the association process.

(11) Familiarity with Language.—Trautscholdt had observed that unfamiliarity with the language increased the proportion of outer associations.

[7] Kraepelin differentiates between weariness and fatigue, the former serving merely as a danger signal for the latter.

(12) The Grammatical Form of the Stimulus.—The uneducated, Jung found, possess a greater tendency to react in the same grammatical form, noun to noun, verb to verb, and adjective to adjective. For the educated, the average correspondence was fifty-one per cent.—for uneducated it was fifty-nine per cent. Verb and adjective stimulus words reduce the number of noun reactions to about half. Verbs and adjectives give rise to a larger number of inner associations. Ziehen observed that verbs and adjectives produce longer reaction times than nouns. The most difficult stimuli are, for educated men, concrete nouns, and for uneducated men abstract nouns.

(13) Attention.—This factor will be considered later in discussing the distraction experiments, and the inability to concentrate as a complex-sign.

(14) Practice.—Wells summarizes the practice effects as follows: (a) They tend to decrease the association time. "Practice shortens the central tendencies of the times, it does not bring down their lower limit very much,"—that is, practice does not affect the most rapid reactions. (b) They tend to remove certain inhibitions, the vocabulary of the subject becoming more available. (c) They tend to decrease the emotive value of the experiment. As a result, this element reduces the value of the association method for complex-diagnosis.

II The Association Series with Reproduction

(1) "*Wiederholungsversuch*" (Recall of Response) (Jung)

This procedure was first used by Jung and was based on the phenomenon of repression (Verdrängung). Since individuals attempt to repress and forget those thoughts and experiences which are out of harmony with prevailing moral and aesthetic concepts, consequently those stimulus words related to any disagreeable, unpleasant or offensive acts or ideas, will not elicit the same response when the identical experimental series is again given.

Jung's method was as follows: He first constructed the regular series of 100 words to which the subject responded. The reaction, both qualitative and quantitative, was noted. After a moderate interval (the following day), the subject was again told to react to the same series, and as far as possible, with exactly the same words. This time only the verbal response was noted. (In Pfenninger's reproduction experiments, the same series was given at eight weekly intervals.) A comparative estimation of results proved that the reactions to words related to a complex were not the same in both cases.

Lipmann found it difficult to estimate failures of reproduction when a synonym or an approximately similar word was given as the second response. In such instances, the number of other coincident complex-indicators ought to be used as a criterion in deciding. Jung, Pappenheim and Peters have shown that false reproduction and long reaction times occur together most remarkably. Schnitzler, however, observed a negative correlation. Langfeld, working on the problem of negative instruction, the subject avoiding one type of response in preference to another, proved that under these conditions the failure of reproduction went as high as 26%.

(2) "*Erinnerungsversuch*" (Recall of Stimulus) (Wertheimer, Lipmann).

First, the association series is given. The response and reaction time are noted. The "Wiederholungsversuch" described in the last section, may or may not follow, it being optional with the examiner. After a reasonable interval, the subject is asked to recall, in any order, as many of the stimulus-words as possible. These are recorded. Lipmann finds that the larger percentage of words remembered will be complex-toned, and that the first words recalled may be of great significance in diagnosis. The repetitions during recall are important,—these also should be recorded. During reproduction, if words appear which were not present in the regular series, a close examination may reveal the relation to the complex of both the incorrectly reported word and the forgotten stimulus. Lipmann remarks that this "Erinnerungs" procedure may result in the subject's gathering together the scattered complex-stimuli in such an order, that the sequence of ideas may almost amount to a voluntary confession.

III The "Aussage" or Reproduction Method

IV The "Aussage"-Association Method

V The Combination Method

In these experiments, the examiner assumes that the subject has had a specific, vivid, emotionally-toned experience. He is then read a story ("Versuchsgeschichte") so constructed by the experimenter as to be very similar in content to the experience in question. The details in the narrative, however, are incomplete, vague and only cleverly approximate the actual events. Having been instructed to pay strict attention, the subject is requested to recall as much of the story as possible. But the details in the narrative and experience being so much

alike, he more or less unconsciously confuses those of one with those of the other, and, as a result, inserts and supplements items which were wholly absent from the story. By this intimate knowledge of details, he easily betrays his familiarity with certain events. He may have previously denied most emphatically the least acquaintance with a single incident. Nevertheless, his responses definitely point to the contrary.

III *The "Aussage" or Reproduction Method.* (Wertheimer.)

This procedure is not to be confused with Jung's. The individual here is asked to reproduce orally the story which had been read to him. Using the technical terms of the "Aussage" Test, this portion of the method is the "Bericht" or report, and may be further supplemented or completed by the "Verhör" (the interrogatory or deposition). The latter may be any one or a combination of these three types. First, the questions may relate to details only, which are *common* to both story and "Tatbestand" (experience, or constellation of facts); second, the questions may yield different responses owing to *differences* in story and "Tatbestand"; third, the questions may relate to details present only in the "Tatbestand." Kramer states that this method may work perfectly in the laboratory, but may fail absolutely in actual application. More data are necessary.

IV *The "Aussage"-association Method.* (Wertheimer.)

Here the subject is given an association series made up of words of these three types: first, those relating to similarities in both the "Tatbestand" and the story; second, those relating neither to the "Tatbestand" nor the story; third, those relating only to the "Tatbestand." The subject is requested to state his associations only to those words which appeared in the story; to all others he is to respond with the word, "nothing." According to Lipmann the guilty easily betray themselves.

V *The Combination Method.* (Lipmann and Wertheimer.)

The following is Lipmann and Wertheimer's adaptation of the Ebbinghaus "Kombinationsmethode." After the subject has heard the "Versuchsgeschichte," a sheet is placed before him containing the text of the story, but from which many details have been omitted. Room is left in the "Kombinationstext" for the proper information to be inserted. This

information (not having been given at all in the story) either must be supplied from the "Tatbestand," or else the text is so arranged as to draw out more or less forcibly a complete description of some incident inaccurately mentioned in the narrative.[8]

Apparatus is arranged so that whenever the subject writes, an electric circuit is closed. It is opened the moment the pencil leaves the paper. A kymograph is used to record these "makes" and "breaks" of current. Long, significant pauses may thus be recorded and the correlations between length of pause and character of the supplementation noted. Attempts at dissimulation are easily discovered, first, by a too frequent response of "Nothing"; second, by too many unmeaning reactions; third, by a greatly retarded reaction procedure. At the end of the experiment, Lipmann and Wertheimer had their subject give an introspective account of his mental activity during the examination. Many of those who were found to have betrayed themselves, were most positive in their insistence that they had said nothing which could in any way reveal the existence of the complex. Rittershaus sees no value in this method.

In all of the three above procedures, it is admitted that innocent as well as guilty individuals will make errors in their reproductions. The point to be emphasized, however, is that the guilty make *significant* ones.

VI *Perception Method.* (Wertheimer and Klein.)

Optic stimuli are presented by means of a tachistoscope. The exposure is made for a very short time. The association series includes (a) purely irrelevant words, (b) complex-words, (c) irrelevant words similar by sight or sound to those of a complex type, (d) incomplete words which might be interpreted by the subject either as irrelevant or complex, e. g.,—CHO-E may be interpreted in terms of the complex as CHOKE, or may be understood by the innocent individual as CHORE or CHOSE.

Results seem to indicate that (a) so-called guilty individuals perceive complex stimuli more quickly than irrelevant, (b) irrelevant stimuli are falsely perceived as complex, (c) incom-

[8] Max Verworn suggests a graphic method whereby an individual is shown a drawing similar in detail to the place where, let us say, a crime was committed. The drawing is not quite accurate. The suspect is asked to reproduce the drawing from memory. The errors may be very significant.

plete stimuli are interpreted more easily as complex than irrelevant.

Instead of perception being visual, it may be auditory. The authors suggest Gutzmann's procedure in the use of a phonograph. Thus the word *coarse* will be heard as *corpse* by the murderer. Some of the advantages in using a phonograph have already been indicated. Besides the ones mentioned, the phonograph adds obscurity and indistinctness to the stimulus, and eliminates any possibility of lip-reading.

VII *Distraction Method.* (Wertheimer and Klein.)

The subject is given two texts, the content of one being related to the "Tatbestand," while the content of the other is quite irrelevant. He is requested to put a line through all "r's" as rapidly as possible. The number of "r's" crossed, the time, errors, and behavior are noted. The results seem to show that the meaning of the text relating to the "Tatbestand" is much more distracting to the rigid and accurate performance of the task.

VIII *Sentence Method.* (Moravcsik.)

The experimental material consists largely of sentences expressive of different emotional states. Sentences of indifferent affective toning are also employed. The subject is requested to respond with whatever comes into his mind. No attempt is made to narrow down the reaction to any particular form, type or to any number of words. Moravcsik experimented only on melancholiacs and maniacs. The following are samples of his material:

Stimulus *Words* (depression)—sadness, pain, suffering, grave, sins.
(exaltation)—joy, riches, dance, laughter.
(indifferent)—garden, house, snow.
Sentences (depression)—How unfortunate I am!
It would be well if I were buried.
My heart is so full of pain.
(exaltation)—The best thing is a long life.
I am full of joy!
(indifferent)—In Winter the snow falls.

He observed that the melancholiac found a group of words expressive of dejection harmonious and desirable, and revolted to those of an exalted type. The reverse was true of the maniac. He also concludes that those possessing a stronger mental balance answer with a single word rather than with a sentence.

IX *The "Ausfrage" Method.* (Marbe, Messer, Bühler and others. Designated "Ausfrage" by Wundt.)

The procedure is that of the simple association experiment. A stimulus word is presented and the subject responds with the first idea coming to consciousness. Immediately following this, however, he is asked to give a complete introspection of all his mental operations during the reaction. This method is of value only where trained introspectionists are acting as subjects. Wundt opposed its use as a psychological experiment, since it lacks the four necessary elements, but Kakise, on the contrary, makes a strong plea for its employment. From one point of view this mode of procedure resembles greatly the usual psychanalytic method.

Since some of these methods have only in one or two cases been given a fair and accurate trial by unbiased yet expert psychometrists, for the detection of crime, it is not surprising to find so large a number of workers in this field skeptical as to their value. We certainly need more data. But, granting their worthlessness for criminal psychology, they still are of great promise to experimentalists interested in the diagnosis of individual complexes and constellations. As yet, the procedures are crude and the technique undeveloped. The methods are waiting for a master-hand at reconstruction and improvement.

G The Complex Indicators ("Komplexmerkmale")

In the earlier association experiments, deviations, peculiarities, errors in response were not regarded as significant. And even to-day, unless one is well acquainted with the more recent contributions in this field, one may be led to commit many farcical errors, such, for example, as those of Schnitzler. During his experiments, any stimulus word not properly understood by the subject was eliminated from the series and another similar one was substituted! This occurred in all cases at least once, and was as frequent as five or six times!! One is naturally led to conclude either that the examiner was very careless in his choice of words or in his pronunciation of them, or that his subjects were peculiarly defective in hearing, or what is more probable and evident, that he seriously neglected observing the importance of failures to hear or understand, especially as to their relation to the complex for which he was searching. On the contrary, an efficient examiner ought to look suspiciously upon every unnatural or forced laugh, cough or movement.

In this connection, it might be advisable to emphasize most strongly the fact that *one* complex-sign by itself should never be regarded as diagnostic. One may venture a judgment only when in possession of an *aggregate* of indicators. Then again, common sense must be used in determining the importance of the several symptoms. Kramer and Stern have observed that different individuals betray their complexes in different ways. Consequently the importance of the separate "Komplexmerkmale" will be differently graded for various persons. Also, A. Gross, Löffler, Kramer and Stern and Rittershaus all emphasize the danger of rendering interpretations on the basis of minutiæ. To quote Löffler, "What cannot be grasped with the hands, ought to be let alone." ("Was nicht mit Händen zu greifen ist, lasse man beiseite.")

Among the skeptics is Heilbronner, who maintains that the large number of complex-symptoms leads to inaccuracies, since to the experimenter with foresight, it is overwhelming, while for one who is careless, it means arbitrariness and caprice. He has no faith in conduct being used as a complex-sign, and believes that the existence in all persons of numerous complexes renders a separate diagnosis very difficult. Rittershaus seems to regard the last criticism as a very telling one. In actual experimentation, however, where one obtains some sort of verbal response, which may later be analyzed by a question or two, the difficulty is not as serious as it is made to appear.

The "Komplexmerkmale" may be classified roughly into three types,—qualitative, quantitive, physiological.

I *Qualitative Complex Indicators*

(1) *Content.*

A subject may often help indicate the existence of specific constellated mental material by giving a response-word of significant meaning.

(2) *Whispered Response.*

A stimulus word disturbing the usual calm of mental activity may call forth a whispered response.

(3) *Failure to Understand.*

The stimulus word is really not misunderstood, but, due to the activity of the "censor" the subject has a strong desire *not* to understand. In one case, Jung found the following to have been misunderstood: hate, love, remorse, failure, pleasant. All were related to a definite complex.

(4) *False Reproduction.* (" Wiederholung.") (Responses.)

This phenomenon has been explained earlier in the paper. The reproduction may occur after a short interval (Jung), or after a series of weekly intervals (Pfenninger). In one of Stein's cases (a woman forger), 44% of her reactions were falsely reproduced. Pfenninger has demonstrated that those stimulus words which during the first experiment, gave rise to no complex signs whatever, showed changes in reproduction (after eight intervals, a week apart), amounting to 2.6 for men, 1.6 for women. Where there was but one complex-sign (lengthened reaction time), the changes amounted to 3.3 for men, 2.4 for women. Where there were more than this one complex indicator, the changes amounted to 4.5 for men, 1.7 for women. He concludes that the greater the number of complex-signs possessed by a stimulus word, the larger will be the number of failures in reproduction; and vice versa, the greater the number of failures in reproduction, the greater will be the number of complex-signs attaching to a stimulus.

(5) *False Recall.* (" Erinnerung.") (Stimuli.)

The subject here is asked to recall the stimulus words in any order. Two types of individuals may be observed, one who tries to keep from betraying himself, and will avoid recalling very many, if any, significant words; the other type, more free and open, who will recall complex-stimuli more rapidly and in larger proportion than insignificant stimuli.

(6) *Perseveration.*

(a) Response.

Sometimes no apparent nexus is observable between stimuli and a certain kind of response which appears more or less frequently throughout the experiment. This disposition has been given the name " perseveration tendency " (" Perseverationstendenz."—Müller-Pilzecker). Perseveration may be due to the presence of a complex or a constellation which dominates consciousness, or to a marked poverty of ideas, or the cause may lie deeper in the psychophysical mechanism. Swoboda emphasizes the importance of regular periods of time upon the recurrence of ideas. One of Jung's subjects showed a perseveration of 5%. On examination, the words were all found to be related to the oppressive heat of the day. Of the repeated responses, two were " snow," and two " perspire." Perseveration may occur because of an impulse to avoid creating a " vacuum," or to break down one already existing.

(b) Stimulus.

A subject may sometimes use some significant stimulus word which appeared earlier in the experiment as the response for succeeding stimuli. Perseveration in this case may be due to any one of the reasons mentioned under the preceding heading.

(c) Affect.

Sometimes the perseveration of an affect may be noted. In such cases, the reaction times are increased. (See Post-critical Responses.) On the contrary, Schnitzler observes that affective perseveration shortens reaction times.

(7) *Inhibition.*

Some trains of thought are inhibited by the subject for reasons of modesty, privacy, fear, shame. Any response bringing these uncomfortable ideas into consciousness is checked, with a resulting increase in reaction time.

(8) *Failure to Respond.*

Aside from explaining that failures to respond may be produced by an "emotional stupidity," Jung states that the failures may be due either to hindrance of verbal expression because of the presence of vivid visual imagery, or of vivid ideas strongly tinged with emotion; or they may be due to a distinct eroticism. Sutherland seriously attacks Jung's explanation. First, he takes exception to the statement, "I call attention to the fact that it is quite indifferent what reason the test person gives for refusal to react"; and secondly, he gives the following as some of the true reasons for failures: unpreparedness, meaning recognized and inhibited, attention focussed on irrelevant matters, meaning not recognized, stimulus misunderstood, no meaning to the stimulus, in doubt of word, ambiguity of stimulus, copious imagery, fascinating visual imagery, voluntary inhibition, articulatory block, competition of reaction words, motor block, absorption in trains of imagery, revery, dreamy, blank. In summing up, he says, "A satisfactory explanation of the failure to react involves a genetic study of each particular case; that a considerable number of factors is or may be responsible for each failure; that many of these factors may be peculiar to the experimental situation. The failure indicates the previous experience of the individual only in a very general manner, and is apparently

not sufficiently specific to use confidently for purposes of diagnosis." It is a bit unfortunate that Sutherland chose so many words which tended naturally to increase the normal number of failures.

In one case, Jung observed that the following words produced failures to react: caress, sick, suffer, kiss.

(9) *Quotations.*

(10) *Titles.*

(11) *Sentences.*

A stimulus may give rise to a mental state which can best express itself by means of a quotation, the title of a book, of a story, or a sentence from a song or poem. It is held by some that this is done in order to veil a secret thought. Jung explains that similarly people often sing songs and tell stories which give an intense secret pleasure, because they contain an idea, or give rise to a feeling which cannot openly be expressed.

(12) *Symbolism.*

A word may sometimes be given in response which possesses a separate, individual meaning for the subject, and acts as a symbol representative of a complex.

(13) *General Concepts Hiding the Meaning.*

What appears as an unimportant, general concept may in reality be only a cloak for some specific complex. For example, Jung cites the case of a young lady to whom he presented the stimulus, "three." The response was, "friends." The subject's later statements made it manifest that she had been painfully disillusioned by three of her intimate friends.

(14) *Addition of the Article.*

For example, "angry"—"the person." "*The* person," in this case, meant the subject's irritable father who severely objected to her relations with the young man she loved.

(15) *Naming of an Object in the Examiner's Room.*

Thinking it inadvisable to express a complex-reaction-word, an individual may begin a search for a substitute. His eyes, wandering about the room, may suddenly light upon some object, whose name he immediately proceeds to use as a surrogate-response.

(16) *Peculiar Form of the Response.*

In order to avoid a direct reply with a consequent betrayal of a complex, a person may sometimes be observed to respond with a phrase, a few incoherent or unrelated words.

(17) *Unusual Response.*

A word which is but seldom given as a response may be regarded as suspicious, and indicative of the existence of a constellation or a complex.

(18) *Errors in Response.*

Since the complex is absorbing the complete attention of the subject, all sorts of errors are liable to occur when attempting to respond to an " alien " stimulus.

(19) *Assimilation.*

Because of the subject's different apperceptive attitude, he gives a *new* and *unusual* meaning to the stimulus word.

(20) *Vacuum.*

The explanation and description of this condition have already been briefly mentioned above.

(21) *Unmeaning Responses.*

These may be of two forms, (a) the qualitative relations between a stimulus and a response are of an unmeaning or senseless character, (b) the response itself is without meaning. Rhymes and sound (Klang) associations are examples of unmeaning reactions.

(22) *Nonsense.*

Here are included those slightly irrelevant responses possessing the merest touch of humor perceptible to the examiner only.

(23) *Incomplete Responses.*

Now and then a subject may react by giving only part of a word or phrase. These " errors " should always be recorded and their relations to the complex closely scrutinized.

(24) *Supplementations of Stimulus Words.*

This activity, especially if more or less frequent, may be regarded as suspicious.

(25) *A-symmetrical Responses.*

The stimulus word, usually of double meaning, is not interpreted in its customary sense. For example, "Aussicht" means both "view" and "appearance;" the stimulus word "mean" may be interpreted by the subject as any of the following: arithmetical average, purpose, import, vulgar, paltry, contemptible, and so on. The complex or constellation generally determines which one of these is to be perceived. Homonyms may also be included under this head,—fair, fare; crews, cruise; muscle, mussel; tare, tear.

(26) *Post-critical Responses.*

Post-critical reactions are those immediately following a critical response. Various experimenters have observed that an emotion may have a post-critical effect, tending usually to increase the reaction time. Heilbronner goes further by maintaining that not only are the next few responses affected by this perseveration, but all of the remaining experiment is absolutely changed. Only a very small number, however, regard this criticism as serious.

(27) *"Versprechen," "Verhören," ("Verlesen.")*

The importance of arranging some stimuli so as to be incorrectly perceived, has already been discussed elsewhere. Examples of "Verlesen" (misread) are, (German) "Mord" for "Mond," (English) "kill" for "hill;" "Verhören" (mishear), (German) "Molch," "Dolch" or "Strolch" for "Olch;" (English) "die" for "buy," "truth" for "truce," "filth" for "fills," "father" for "farther," "arms" for "alms." As for "Versprechen" (misspeak), the Freudians have adequately emphasized its significance for complex-diagnosis. In any of these mechanisms the error may be wilful or unconscious. Also, the response-word may be directly related to the complex or may be the expression of a wish that the stimulus word were different.

(28) *"Komplexvertreter." (Complex-surrogate.)*

In such cases the subject keeps one word, usually, in reserve, in order to substitute it for complex-responses. Wells cites a

case. To the words "useless," "husband," "honor," and "against," the response in each instance was "word." This was accompanied every time by a long reaction period. On the basis of other evidence, however, he denies that this is a true example of "Komplexvertreter."

(29) *Translations.*

To avoid giving a suspicious response, an individual may not infrequently translate the stimulus into a different language. Sometimes the reaction word is expressed in a foreign tongue.

(30) *Interjections or Single Letters.*

These are sometimes uttered as response words. In most cases, one is safe in regarding them as suspicious.

II. *Quantitative Complex Indicator*

The quantitative complex indicator is the reaction time. The reaction time is usually regarded as the interval between the giving of the stimulus word (the stop-watch or chronoscope being started on the accented syllable), and the pronouncing of the reaction word.

This general reaction time is composed of seven or eight subdivisions. Ziehen, Claparède and Jung have attempted to clearly distinguish these—thus:

(1) The time of transfer of the sound to the ear of the subject,

(2) the transfer from the periphery to the auditory center,

(3) the recognition of the word,—what Jung calls "primary identification,"

(4) the understanding of the word,—called by Jung, "secondary identification,"

(5) the calling forth of another idea (this is really the *pure* association),

(6) the naming of this idea in consciousness,

(7) the inner stimulation of the verbo-motor apparatus (and if a key is to be pressed, also a stimulation of the motor centers controlling hand movements),

(8) the time between this stimulation and expression.

The gross reaction time has been found to be:

Aschaffenburg's figures	1.2 to 1.4 seconds
Galton's figures	1.3 seconds
Trautscholdt's figures	0.9 to 1.2 seconds
Féré's figures	1.6 for men, 1.8 for women
Jung's (already mentioned)	1.8 average.

According to Jung, a 0.5-second variation over the average may be regarded as suspicious. That is probably too short an allowance,—one second is probably better.

It is generally agreed that the stop-watch is, from many points of view, the better instrument with which to measure association time.

III. *Physiological Complex Indicators*

The physiological complex indicators will merely be mentioned, since, as yet, we know but little of their value as practical instruments for the detection of complexes. It is at present assumed that unusual changes produced in any of the following, by the perception of a stimulus word, may be diagnostic of a complex:

(1) *Psychogalvanic Reflex.*
(2) *Electro-motor Heart Flow.*
(3) *Pulse.*
(4) *Respiration.*
(5) *Blood Pressure.*
(6) *Involuntary Movements, or Tremors of the Hands or the Limbs.*
(7) *Ataxiagraph.* (*Involuntary Bodily Sway.*)
(8) *Knee-jerk.*
(9) *Lifting Ability of the Finger.* (*Ergograph.*)
(10) *Tapping Test.*
(11) *Strength of Grip.*
(12) *Facial Expression.* (*Reddening, etc.*)
(13) *Tone of Voice in Response.*
(14) *Ability to Concentrate.* (*Disturbances of Attention.*)
(15) *General Conduct and Behavior.* (*Coughing, Clearing the Throat, etc.*)

* * * * * *

It is generally admitted that a large number of the complex-indicators mentioned above may be purely accidental and without any complex-significance whatever. For example, a person with a cold in the head may not hear very well, he may give a wrong response, may make some unusual, restless movements, may cough here and there, and tears even may begin to flow from his eyes. The experimenter cannot be too careful in discriminating a forced, artificial behavior from a purely natural one. Unless one is heedful of this fact, most absurd results may be obtained.

The complex-indicators have not been arranged in order of importance, for as previously mentioned, each individual has

an order of his own. Rittershaus emphasizes the fact that since uneducated possess a much smaller vocabulary, they may give longer reaction times when presented with slightly strange words; that, coming from a lower level, they are not accustomed to think in single words or ideas, but in sentences, and that they often approach the examination as a kind of intelligence test, thinking that they must under no circumstances give anything but an intelligent answer. In such cases, it is not surprising to observe failures to respond, lengthening of reaction times, false reproductions, sentence responses, etc. These complex-indicators are of practically no significance in their cases.

The experimenter should try to observe as many symptoms as is possible without interfering in any way with the mental composure of the subject. For that reason, too much apparatus in the detection of physiological complex-indicators is not advisable.

Rittershaus' experimental procedure might be mentioned here. There are four experimenters: the first gives the association series and records the reaction word and the time; the second has a copy of association material and sits a little on the side, paying particular attention to the behavior of the subject, noting any physiological changes or changes in behavior; the third is a disinterested individual who is not present during the examination. After it is over, he takes the results and works them into curve form; and the fourth is one who knows nothing of the particular subject tested, and is ignorant of all direct experimental data. He studies the curve and draws his conclusions from it regarding the existence of complexes. When that is done, all get together and talk it over.

Before the experimenter can feel properly qualified to evaluate results, he must have had a wide experience in applying this method to different types of normal adults, to children, to feeble-minded, and to insane. To quote Jung: "The association method is a tender instrument which can only be directed by the experienced hand, and one must pay dearly for his experience before the application of this method is accurately understood. Consequently, as it now stands, one must not expect too much; it is, however, full of great possibilities."

H. Conclusions

I. *Pedagogical*

Ziehen places strong emphasis upon the fact that experimental studies of association are necessary for a scientific pedagogy. This matter has been reiterated by Meumann.

Pfister clearly indicates the relation of the complex to the hygiene of the school child. A number of psychanalysts are now studying the complex as a moulder of character, and as a determiner of the future.

From the data already considered, we may infer the following:

(1) Every one of us possesses a different mass of associated complexes. In the school room, consequently, an explanation to one will have an entirely different meaning to another pupil.

(2) Education fixes certain associations between ideas. These associations are not easily broken down. Sometimes they persist for the whole life-time of an individual. What great care and caution must be exercised by the teacher!

(3) Galton has shown that the largest part of our associations are "histrionic," of the motor or visual type. For that reason, it should be emphasized that the greater the amount of objective experiences obtained by the child, the better equipped will he be later. These experiences should be not only perceptive, but also *affective*. Ziehen and Meumann found that children between six and thirteen who gave a larger per cent. of "individual vorstellungen" (particular ideas), were the brighter. These particular ideas naturally give the child a sound basis on which to build his abstractions.

(4) Galton also pointed out that nearly 50% of our oft-repeated associations date back to childhood and youth. How important is it then, to fill the mind of that period with rich, numerous, and concrete associations.

(5) The emotions greatly affect the facility of associations. Pleasant emotions help, unpleasant ones retard, the process. Consequently, our aim in education should be for pleasurable feelings all the time, in order to facilitate the acquisition of knowledge. "Happiness first,—all else follows," to quote the Vineland motto.

(6) Emma Fürst has shown how the association complexes of the family have an enormous directing effect upon the formation of complexes in the children. The family constellations (what Jung calls the "infantile milieu") have an enormous effect upon the character formation of the child.

Adler has clearly emphasized the importance of the "manly protest" at the dawn of puberty. At that period a most significant revolution, both mental and physical, is going on in the individual. The spirit and desire for freedom, for self-expression, are raging in the entire organism. Consequently, a child who is bound down by, and too much dependent upon the family and its members, may suffer serious mental injury.

(7) Children's questions ought to be given more earnest consideration. Our treating their every inquiry as a matter for mirth is absolutely unjust. Truth and seriousness ought to prevail instead.

(8) If the Freudian concepts of infantile sexuality are true, then we may hopefully look to psychanalysis not only as the most essential neurotic prophylactic, but also as a most important factor in determining the directions in which personality is expected to develop. As regards the first, Pfister already has indicated how certain abnormalities in school children may be psychanalyzed and removed.

II. *Psychological*

If the psychology of character has a future then the search for complexes is going to play an enormous part in its development. At present, we have not advanced very far beyond the classification of the temperaments. In Wundt's psychology, the four-fold arrangement of the Greeks still persists. Other classifications have been suggested by Dessoir, Bahnsen, Höffding, Ebbinghaus, Ribot, Kraepelin, Binet and a large number of others, but they are all purely theoretical. And one is painfully astonished to note in a recent German article on personality, but one(!) reference to the work of a psychanalyst among 130 others. "Komplexlehre" was entirely neglected in this study.

The usual definition of character focusses on the term "expression," but a new definition, in the light of complex and constellation studies, will go back to the *motives* for this "expression." The one is objective, the other subjective.

Sutherland has indicated that trains of association are very significant for (1) information regarding the condition of mentality—normal or abnormal; (2) range of information in any particular subject; (3) logical sequence of the thought processes.

Further research in this extensive field of the complex will no doubt reveal the closer union between psychology and eugenics. Are the tendencies to acquire certain particular complexes hereditary? Are complexes, as such, hereditary? The studies of Emma Fürst seem, on the surface, to give a positive answer to at least the first question.

In closing this paper, I cannot but emphasize the importance of the complex and the constellation as factors shaping our destinies, and the importance of the association method in determining what these complexes and constellations are.

J. Bibliography

1. Aptekmann, Esther. Experimentelle Beiträge zur Psychologie des psychogalvanischen Phänomens. *Jahrb. f. Psychoanalyt. u. psychopatholog. Forschgn.*, III., 1912, 591-620.
2. Aschaffenburg, Gustav. Experimentelle Studien über Assoziationen. Kraepelin; *Psycholog. Arbeiten*, I, 1896, 209-299; II, 1899, 1-83; IV, 1904, 235-373.
3. Atherton, M. Valerie and Washburn, M. F. Mediate Associations Studied by the Method of Inhibiting Associations: An Instance of the Effect of "Aufgabe." *Amer. J. Psychol.*, XXIII, 1912, 101-109.
4. Bawden, H. A Study of Lapses. *Psychol. Rev. Mon. Supp.*, III, 4, 1900, 122 p.
5. Binet, Alfred. Le diagnostique judiciaire par le méthode des associations. *Année psychol.*, XVI, 1910, 372-383.
6. Binswanger, L. Über das Verhalten des psychogalvanischen Phänomens beim Assoziations experiment. Jung: *Diagnos. Assoziationsst*, II, 1910, 113-195; also *J. f. Psychol. u. Neurol.*, X, 1907-1908, 149-181; XI, 1908, 65-95, 133-153.
7. Birnbaum, Karl. Über den Einfluss von Gefühlsfaktoren auf die Assoziationen. *Monatsschr. f. Psychiat. u. Neurol.*, XXXII., 1912, 95-123; 194-220.
8. Bleuler, E. Über die Bedeutung von Assoziationsversuchen. Vorwort; *J. f. Psychol. u. Neurol.*, III, 1904, 49-54; also Jung; *Diagnos. Assoziationsst*, I, 1906, 1-6.
9. —— ——. Bewusstsein und Assoziation. *J. f. Psychol. u. Neurol.*, VI, 1905-1906, 126-154; also Jung; *Diagnos. Assoziationsst*, I, 1906, 229-257.
10. Bolte, ——. Assoziationsversuche als diagnostisches Hilfsmittel. *Allg. Zschr. f. Psychiat.*, LXIV, 1907, 619-630.
11. Brill, Abraham Arden. Psychanalysis; its theories and practical application. Phila. and London, W. B. Saunders, 1913. 337 p.
12. Burr, Emily T. and Geissler, L. R. An Introspective Analysis of the Association-Reaction Consciousness. *Amer. J. Psychol.*, XXIV, 1913, 564-569.
13. Chase, Harry Woodburn. Psychoanalysis and the Unconscious. *Ped. Sem.*, XVII, 1910, 281-327.
14. Claparède, Ed. L'Association des idées. Paris: Doin, 1903. 426 p.
15. —— ——. La psychologie judiciaire. *Année psychol.*, XII, 1905, 295-302.
16. Cordes, G. Experimentelle Untersuchungen über Assoziationen. *Philos. Stud.*, XVII, 1901, 30-77.
17. Féré, Charles. The Pathology of the Emotions. London: University Press, 1899, 525 p.
18. Franz, S. I. and White, W. A. The Use of Association Test in Determining Mental Contents. U. S. Gov. Hos. for the Insane. Bull. I, 1909, 55-71.
19. Freud, Sigmund. Tatbestandsdiagnostik und Psychoanalyse. *Arch. f. Kriminalanthropol. u. Kriminalistik*, XXVI, 1906, 1-10.
20. —— ——. Zur Psychopathologie des Alltagslebens. Berlin: Karger, 1907, 132 p.

21. —— ——. Tatbestandsdiagnostik und Psychoanalyse. In Sammlung kleiner Schriften zur Neurosenlehre. Leipzig u. Wien: Deuticke, II, 1909, pp. 111-121.
22. —— ——. The Origin and Development of Psychoanalysis. *Amer. J. Psychol.*, XXI, 1910, 181-218.
23. —— ——. Über Psychoanalyse; fünf Vorlesungen gehalten zur 20 jährigen Gründungsfeier der Clark University in Worcester, Mass., Sept., 1909. Lpz.: Deuticke, 1910, 62 p.
24. FÜRST, EMMA. Statistische Untersuchungen über Wortassoziationen und über familiäre Übereinstimmung im Reaktionstypus bei Ungebildeten. *J. f. Psychol. u. Neurol.*, IX, 1907, 243-278, also Jung: *Diagnos. Assoziationsst*, II, 1910, 77-112.
25. GALLUS, KURT. Über Assoziationsprüfung. *Zschr. f. Psychother. u. mediz. Psychol.*, II, 1910, 106-127.
26. GALTON, FRANCIS. Psychometric Experiments. *Brain*, II, 1879, 149-162, also *19th Century*, V, 1879, 425-433.
27. —— ——. Inquiries into Human Faculty and its Development. London: MacMillan & Co., 1883, pp. 182-203.
28. GEISSLER, L. R. A preliminary Introspective Study of the Association-Reaction Consciousness. *Amer. J. Psychol.*, XXI, 1910, 597-602.
29. —— ——. Analysis of Consciousness under Negative Instruction. *Amer. J. Psychol.*, XXIII, 1912, 183-213.
30. GIESE, FRITZ. Das Ich als Komplex in der Psychologie. *Arch. f. d. ges. Psychol.*, XXXII, 1914, 120-165.
31. GRABOWSKY, ADOLF. Die Anwendung der psychologische Tatbestandsdiagnostik in der Strafrechtspraxis. *Monatsschr. f. Kriminalpsychol. u. Strafrechtsref*, III, p. 163.
32. —— ——. Zur Frage der psychologische Tatbestandsdiagnostik. *Zeitschr. f. d. ges. Strafrechtswiss*, XVI.
33. GROSS, A. Zur psychologischen Tatbestandsdiagnostik als kriminalistisches Hilfsmittel. *Beitr. zur. Psychol. der Aussage*, II, 1904-1906, 436-439.
34. —— ——. Zur psychologische Tatbestandsdiagnostik. *Monatsschr. f. Kriminalpsychol. u. Strafrechtsref*, II, 1905, 182-184.
35. —— ——. Die Assoziationsmethode im Strafprozess. *Zeitschr. f. d. ges. Strafrechtswiss*, XXVI, 1905, 19-40.
36. —— ——. Kriminalpsychologische Tatbestandsforschung. *Jurist.-psychiat. Grenzfr.*, VII, 1907.
37. —— ——. Zur Frage des Wahrnehmungsproblems. Ref. in *Beitr. zur Psychol. der Aussage*, II, 1904-1906, 258-264.
38. GROSS, H. Zur psychologische Tatbestandsdiagnostik. *Arch. f. Kriminalanthrop. und Kriminalistik*, XIX, 1905, 49-59.
39. HAGGERTY, M. E. and KEMPF, E. J. Suppression and Substitution as a Factor in Sex Differences. *Amer. J. Psychol.*, XXIV, 1913, 414-425.
40. HEILBRONNER, KARL. Die Grundlagen der psychologische Tatbestandsdiagnostik. *Zschr. f. d. ges. Strafrechtswiss*, XXVII, 601.
41. HENKE, F. G. and EDDY, M. W. Mental Diagnosis by the Association Reaction Method. *Psychol. Rev.*, XVI, 1909, 399-409.
42. HUBER, EDWIN. Assoziationsversuche an Soldaten. *Zschr. f. Psychol. u. Physiol. d. Sinnersorgane*, LIX, 1911, 241-272.

43. HUG-HELLMUTH, H. VON. Aus dem Seelenleben des Kindes, eine psychoanalytische Studie. Lpz.: Deuticke, 1913, 170 p. (Schriften zur angew. Seelenkunde, Heft. 15.)
44. JELLIFFE, SMITH ELY. The Technique of Psychoanalysis. *Psychoanalytic Rev.*, I, 1913-1914, 63-75; 178-186; (to be continued).
45. JONES, ERNEST. The Practical Value of the Word-Association Method in the Treatment of the Psycho-Neuroses. *Rev. of Neurol. and Psychiat.*, VIII, 1910, 641-672.
46. —— ——. Papers on Psychoanalysis. London, Baillière, 1913, pp. 206-240.
47. JUNG, CARL G. Über Simulation von Geistesstörung. *J. f. Psychol. u. Neurol.*, II, 1903, 181-201.
48. —— ——. Experimentelle Beobachtungen über das Erinnerungsvermögen. *Centralb. f. Nervenheilk. u. Psychiat.*, XXVIII (n. s. XVI), 1905, 653-666.
49. —— ——. Zur psychologischen Tatbestandsdiagnostik. *Centralbl. f. Nervenheilk. u. Psychiat.*, XXVIII (n. s. XVI), 1905, 813-815.
50. —— ——. Analyse der Assoziationen eines Epileptikers. *J. f. Psychol. u. Neurol.*, V, 1905, 73-90, also Jung: *Diagnos. Assoziationsst.*, I, 1906, 175-192.
51. —— ——. Über das Verhalten der Reaktionszeit beim Assoziations experimente. *J. f. Psychol. u. Neurol.*, VI, 1905-1906, 1-36, also Jung: *Diagnos. Assoziationsst.*, I, 1906, 193-228.
52. —— ——. Psychoanalyse und Assoziations experiment. *J. f. Psychol. u. Neurol.*, VII, 1905-1906, 1-24, also Jung: *Diagnos. Assoziationsst.*, I, 1906, 258-281.
53. —— ——. Die psychologische Diagnose des Tatbestandes. *Jurist.-psychiat. Grenzfr.*, IV, 1906.
54. —— ——. On Psychophysical Relations of the Associative Experiment. *Abnorm. Psychol.*, I, 1906-1907, 247-255.
55. —— ——. Assoziation, Traum und hysterisches Symptom. *J. f. Psychol. u. Neurol.*, VIII, 1906-1907, 25-60, also Jung: *Diagnos. Assoziationsst*, II, 1910, 31-66.
56. —— ——. Literaturbericht (O. Lipmann und M. Wertheimer: Tatbestandsdiagnostische Kombinationsversuche). *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane*, L, 1909, 301.
57. —— ——. Über die Reproduktionsstörungen beim Assoziationsexperiment. *J. f. Psychol. u. Neurol.*, IX, 1907, 188-197, also Jung: *Diagnos. Assoziationsst.*, II, 1910, 67-76.
58. —— ——. The Association Method. *Amer. J. Psychol.*, XXI, 1910, 219-269.
59. —— ——. The Theory of Psychoanalysis. *Psychoanalytic Rev.*, I, 1913-1914, 1-40; 153-177; to be continued.
60. JUNG, CARL G. und RIKLIN, FR. Experimentelle Untersuchungen über Assoziationen Gesunder. *J. f. Psychol. u. Neurol.*, III, 1904. 55-83; 145-164; 193-215; 283-308; IV, 1904-1905, 24-67. Jung: *Diagnos. Assoziationsst.*, I, 1906, 7-145.
61. KAKISE, HIKOZO. A Preliminary Experimental Study of the Conscious Concomitants of Understanding. *Amer. J. Psychol.*, XXII, 1911, 14-64.
62. KENT, GRACE HELEN and ROSANOFF, A. J. A Study of Association in Insanity. *Amer. J. of Insanity*, LXVII, 1910, 317-377.

63. KRAEPELIN, E. Über die Beeinflussung einfacher psychischer Vorgänge. Jena: Fischer, 1892, 258 p.
64. —— ——. Der psychologische Versuch in der Psychiatrie. Kraepelin: *Psycholog. Arbeiten,* I, 1896, 1-91.
65. KRAMER, F. Literaturbericht. *Beitr. zur. Psychol. der Aussage,* II, 1904-1906, 580-586.
66. KRAMER, F. und STERN, W. Selbstverrat durch Assoziation. *Beitr. zur. Psychol. der Aussage,* II, 1904-1906, 457-488.
67. KRAUS, O. Psychologische Tatbestandsdiagnostik. *Monatsschr. f. Kriminalpsychol. u. Strafrechtsref,* II, 1905, 58-61.
68. KUTZINSKI, ARNOLD. Über die Beeinflussung des Vorstellungsablaufes durch Geschichtskomplexe bei Geisteskranken. *Monatsschr. f. Psychiat. u. Neurol.,* XXXIII, 1913, 78-109; 159-178; 254-279.
69. LANGFELD, HERBERT SIDNEY. Suppression with Negative Instruction. *Psychol. Bull.,* VII, 1910, 200-208.
70. —— ——. Suppression with Negative Instruction. *Psychol. Rev.,* XVIII, 1911, 411-424.
71. LEACH, HAZEL M. and WASHBURN, M. F. Some tests by the association-reaction method of mental diagnosis. *Amer. J. Psychol.,* XXI, 1910, 162-167.
72. LEDERER, MAX. Psychologische Tatbestandsdiagnostik. *Zschr. f. d. ges. Strafrechtswiss,* XXVI, 1906, 488-506.
73. LEVY-SUHL, MAX. Über experimentelle Beeinflussung des Vorstellungsverlaufs bei Geisteskranken. *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane,* XLII, 1906, 128-161; XLV, 1907, 321-340; LIX, 1911, 1-90; also Leipzig: Barth, 1911, pp. 142.
74. —— ——. Über Einstellungsvorgänge in normalen und anormalen Seelenzuständen. *Zschr. f. Psychother. u. mediz. Psychol.,* II, 1910, 141-164.
75. LEY, AUG. et MENZERATH, PAUL. L'étude expérimentale de l'assoc. des idées dans les maladies mentales. Gand: Van der Häghen, 1911, pp. 199.
76. LIPMANN, OTTO. Sammelberichte. Neuere Arbeiten zur Psychologie der Aussage. (Wertheimer u. Klein—"Psychologische Tatbestandsdiagnostik.") *Journal für Psychologie und Neurologie,* III, 1904, 249.
77. —— ——. Literaturbericht. *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane,* XLIII, 1906, 157-158; XLVI, 1907-1908, 306-307.
78. —— ——. Grundriss der Psychologie für Juristen. Leipzig: Barth, 1908, pp. 70-78, 2nd ed., 1914.
79. —— ——. Analyses bibliographiques Psychologie judiciaire. (Otto Lipmann et M. Wertheimer: Tatbestandsdiagnostische Kombinationsversuche.) *Année psychol.,* XIV, 1908, 493-494.
80. —— ——. Die Spuren interessebetonter Erlebnisse und ihre Symptome. (Theorie, Methoden und Ergebnisse der "Tatbestandsdiagnostik.") *Beihefte, Zschr. f. angew, Psychol.,* I, 1911, 1-96.
81. LIPMANN, OTTO und WERTHEIMER, MAX. Tatbestandsdiagnostische Kombinationsversuche. *Zschr. f. angew. Psychol.,* I, 1907-1908, 119-128.
82. LÖFFLER, ——. Zur psychologische Tatbestandsdiagnostik. *Monatschrift f. Kriminalpsychol. u. Strafrechtsref.,* III, 449.
83. MAYER, A. and ORTH, J. Zur qualitativen Untersuchung der Assoziation. *Zschr. f. Psychol.,* XXVI, 1901, 1-13.

84. MENZERATH, PAUL. Die sogenannten Komplexmerkmale beim Assoziations-experiment. (Discussion by Sommer, Weygandt, Stern, Wertheimer, Dittrich.) Bericht, 5 Kongress f. experim. Psychol. Leipzig: Barth, 1912, pp. 170-175.
85. MEYER, A. Normal and Abnormal Associations. *Psychol. Bull.*, II, 1905, 242-259.
86. MOLL, ALBERT. Die Behandlung sexueller Perversionen mit besonderer Berücksichtigung der Assoziationstherapie. *Zschr. f. Psychotherapie u. mediz. Psychol.*, III, 1911, 1-29.
87. MOORE, JARED S. The Articulation of the Concepts of Normal and Abnormal Psychology. *Amer. J. Psychol.*, XXV, 1914, 283-287.
88. MORAVCSIK, E. Experimente über das psychogalvanische Reflexphänomen. *J. f. Psychol. u. Neurol.*, XVIII, 1911, 186-199.
89. MORAVCSIK, ERNST EMIL. Diagnostische Assoziationsuntersuchungen. *Allg. Zschr. f. Psychiat.*, LXVIII, 1911, 626-673.
90. MÜLLER, VICTOR J. Zur Kenntnis der Leitungsbahnen des psychogalvanischen Reflexphänomens. *Monatsschr. f. Psychiat. u. Neurol.*, XXXIII, 1913, 235-253.
91. MÜNSTERBERG, HUGO. The Third Degree. *McClure's Magazine*, XXIX, 1907, 614-622.
92. —— ——. On the Witness Stand. New York: McClure, 1908, pp. 71-110.
93. NUNBERG, H. Über körperliche Begleiterscheinungen assoziativer Vorgänge. *J. f. Psychol. u. Neurol.*, XVI, 1910, 102-128, also *Diagnos. Assoziationsst.*, II, 1910, 196-222.
94. OFFNER, MAX. Das Gedächtnis. Berlin: Reuther und Reichard, 1911, pp. 153-154.
95. PELLETIER, M. Les lois morbides de l'association des idées. Paris: Rousset, 1904, 151 p.
96. PETERSON, FREDERICK and JUNG, CARL G. Psycho-physical Investigations with the Galvanometer and Pneumograph in Normal and Insane Individuals. *Brain*, XXX, 1907, 153-218.
97. PFENNINGER, W. Untersuchungen über die Konstanz und den Wechsel der psychologischen Konstellation bei Normalen und Frühdementen (Schizophrenen). *Jahrb. f. Psychoanalyt. u. Psychopatholog. Forschgn.*, III, 1912, 481-524.
98. PFISTER, O. Die psychanalytische Methode; eine erfahrungswissenschaftlich-systematische Darstellung. (*Pädagogium*, v. I.) Lpz.: Klinkhardt, 1913, 512 p.
99. POTOTZKY, C. Die Verwertbarkeit des Assoziationsversuchs für die Beurteilung der traumatischen Neurosen. *Monatsschr. f. Psychiat. u. Neurol.*, XXV, 1909, 521-529.
100. PRINCE, MORTON. The Unconscious. *J. Abnorm. Psycol.*, III, 1908-1909, pp. 261-297; pp. 335-353; pp. 391-426. Also N. Y.: Macmillan, 1914, pp. 549.
101. RANSCHBURG, PAUL und BÁLINT, EMERICH. Über quantitative und qualitative Veränderungen geistiger Vorgänge im hohen Greisenalter. *Allg. Zschr. f. Psychiat.*, LVII, 1900, 689-718.
102. READ, CHARLES F. Application of the Word-Association Method to an Acute Psychosis. *Amer. J. of Insanity*, LXVIII, 1911-1912, 671-681.

103. RIKLIN, FR. Analytische Untersuchungen der Symptome und Assoziationen eines Falles von Hysterie. *Psychiat.-neurol. Wochenschr.*, 1905, p. 449.
104. —— ——. Kasuistische Beiträge zur Kenntnis hysterischer Assoziationsphänomene. *J. f. Psychol. und Neurol.*, VII, 1905-1906, 223-252; also *Diagnos. Assoziationsst*, II, 1910, 1-30.
105. RITTERSHAUS, ERNST. Über Tatbestandsdiagnostik. Vereinsbericht (Vorläufige Mitteilung). *Centralbl. f. Nervenheilk. u. Psychiat.*, XXXI, 1908, 877-878.
106. —— ——. Die Komplexforschung. *J. f. Psychol. u. Neurol.*, XV, 1909-1910, 61-83; 184-220; XVI, 1910, 1-43.
107. —— ——. Zur psychologischen Differentialdiagnose der einzelnen Epilepsieformen. *Arch. f. Psychiat. u. Nervenkrankh*, XLVI, 1910, 1-93; 464-545.
108. —— ——. Die "Spuren interessebetonter Erlebnisse" und die "Komplexforschung." *Zschr. f. d. ges. Neurol. u. Psychiat.*, VIII, 1911-1912, 273-283.
109. RUSK, ROBERT R. Experiments on Mental Association in School Children. *Brit. J. Psychol.*, III, 1909-1910, 349-385.
110. SCHNITZLER, JOHANN GUSTAV. Experimentelle Beiträge zur Tatbestandsdiagnostik. *Zschr. f. angew. Psychol.*, II, 1908-1909, 51-91.
111. SCHOLL, ——. Versuche über die Einführung von Komplexen in die Assoziationen von Gesunden und Geisteskranken. Sommer: *Klinik für psychische u. nervöse Krankh.*, III, 1908, 197.
112. SCRIPTURE, E. W. Experiments on Subconscious Ideas. *J. Amer. Med. Assoc.*, L, 1908, 521-523.
113. SEMON, RICH. Die Mneme als erhaltendes Prinzip im Wechsel des organischen Geschehens. Leipzig: Engelmann, 2 Aufl., 1908, 360 p.
114. SIDIS, BORIS and KALMUS, H. T. The Study of Galvanometric Deflections due to Psycho-physiological Processes. *Psychol. Rev.*, XV, 1908, 391-396; XVI, 1909, 1-35.
115. SOMMER, R. Lehrbuch der psychopathologischen Untersuchungsmethoden. Berlin, Wien: Urban & Schwarzenberg, 1899, p. 326-388.
116. STEIN, PHILIPP. Tatbestandsdiagnostische Versuche bei Untersuchungsgefangenen. *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane*, LII, 1909, 161-237.
117. STERN, WILLIAM. Mitteilungen. Beitr. z. Psychol. der Aussage, II, 1904-1906, 275-277, 440-441.
118. —— ——. Abstracts of Lectures on the Psychology of Testimony and on the Study of Individuality. *Amer. J. Psychol.*, XXI, 1910, 270-282.
119. SUTHERLAND, ARTHUR H. Critique of Word Association Reactions. An Experimental Study. Dissertation, Univ. of Chicago, 1913, pp. 46.
120. SWOBODA, HERMANN. Die Perioden des Menschlichen Organismus. Lpz.: Deuticke, 1904, 135 p.
121. TRAUTSCHOLDT, MARTIN. Experimentelle Untersuchungen über die Associationen der Vorstellungen. Wundt's *Philos. Stud.*, I, 1883, 213-250.

122. UMPFENBACH, ——. Literaturbericht. *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane*, XXXIX, 1905, 222-223; XLI, 1906, 69; XLIV, 1907, 142-143; XLV, 1907, 298-299.
123. VERAGUTH, OTTO. Das psychogalvanische Reflexphänomen. *Monatsschr. f. Psychiat. u. Neurol.*, XXI, 1907, 387; also Berlin: Karger, 1909, 187 p.
124. WEBER, ERNST. Der Einfluss psychischer Vorgänge auf den Körper. Berlin: Springer, 1910, 426 p.
125. WEHRLIN, K. Über die Assoziationen von Imbezillen und Idioten. *J. f. Psychol. u. Neurol.*, IV, 1904-1905, 109-123; 129-143; also Jung: *Diagnos. Assoziationsst.*, I, 1906, 146-174.
126. WELLS, FREDERIC LYMAN. Some Properties of the Free Association Time. *Psychol. Rev.*, XVIII, 1911, 1-23.
127. —— ——. A Preliminary Note on the Categories of Association Reactions. *Psychol. Rev.*, XVIII, 1911, 229-233.
128. —— ——. Practice Effects in Free Association. *Amer. J. Psychol.*, XXII, 1911, 1-13.
129. —— ——. The Question of Association Types. *Psychol. Rev.*, XIX, 1912, 253-270.
130. WELLS, FREDERIC LYMAN and CADY, FREDERIC B. M. A Critique of the Psycho-Galvanic Reflex with some Experiments. (Abtract of the Paper read at a Meeting of the New England Society of Psychiatry.) *Amer. J. of Insanity*, LXV, 1908-1909, 164-166.
131. WELLS, FREDERIC LYMAN and FORBES, ALEXANDER. On Certain Electrical Processes in the Human Body and their Relation to Emotional Reactions. *Arch. of Psychol.*, II, No. 16, 1908-1911, Mar., 1911, 39 p.
132. WERTHEIMER, MAX. Experimentelle Untersuchungen zur Tatbestandsdiagnostik. *Arch. f. d. ges. Psychol.*, VI, 1906, 59-131.
133. —— ——. Literaturbericht—Zur Tatbestandsdiagnostik. *Arch. f. d. ges. Psychol.*, VII, 1906, 139-140.
134. —— ——. Tatbestandsdiagnostische Reproduktionsversuche. *Arch. f. Kriminalanthropol. u. Kriminalistik*, 1906, p. 293.
135. WERTHEIMER, MAX und KLEIN, JULIUS. Psychologische Tatbestandsdiagnostik. *Arch. f. Kriminalanthropol. u. Kriminalistik*, XV, 1904, 72-113.
136. WEYGANDT, WILHELM. Zur psychologischen Tatbestandsdiagnostik. *Monatsschr. f. Kriminalpsychol. u. Strafrechtsref*, II, 1905, pp. 435-438.
137. WHITE, WM. A. Theory of the "complex." *St. Louis Interstate Med. Journ.*, XVI, 1909, 243-258.
138. —— ——. Mental Mechanisms. *Nervous and Mental Disease Monograph Series*, No. 8. N. Y.: J. of Nerv. & Mental Disease Publ. Co., 1911, 151 p.
139. WRESCHNER, ARTHUR. Eine experimentelle Studie über die Assoziation in einem Falle von Idiotie. *Allg. Zschr. f. Psychiat.*, LVII, 1900, 241-339.
140. —— ——. Die Reproduktion und Assoziation von Vorstellungen. *Zschr. f. Psychol. u. Physiol. d. Sinnesorgane. Ergänzungsband* 3, Teil I, 1907, 328 p., Teil II, 1909, 599 p.
141. WUNDT, WILHELM. Grundzüge der physiologischen Psychologie. Engelmann: Leipzig, III, 1911, pp. 436-456; 519-543.

142. YERKES, ROBERT M. and BERRY, CHARLES S. The Association Reaction Method of Mental Diagnosis. (Tatbestandsdiagnostik.) *Amer. J. Psychol.*, XX, 1909, 22-37.
143. ZIEHEN, TH. Die Ideenassoziation des Kindes. Sammlung von Abhandlungen aus dem Gebiete der pädagogischen Psychologie und Physiologie. Vol. I, Heft 6, 1898, 1-66; Vol. III, Heft 4, 1900, 1-59.
144. —— ——. Leitfaden der physiologischen Psychologie. Jena: G. Fischer, 1906, p. 176-204.

K. APPENDIX

A TABULAR LIST OF COMPLEX INDICATORS

I. *Qualitative*

(1) Content
(2) Whispered Response
(3) Failure to Understand
(4) False Reproduction
(5) False Recall
(6) Perseveration
  (a) Response
  (b) Stimulus
  (c) Affect
(7) Inhibition
(8) Failure to Respond
(9) Quotations
(10) Titles
(11) Sentences
(12) Symbolism
(13) General Concepts Hiding the Meaning
(14) Addition of the Article
(15) Naming of an Object in the Examiner's Room
(16) Peculiar Form of the Response
(17) Unusual Response
(18) Errors in Response
(19) Assimilation
(20) Vacuum
(21) Unmeaning Responses
(22) Nonsense
(23) Incomplete Responses
(24) Supplementations of Stimulus Words
(25) A-symmetrical Responses
(26) Post-critical Responses
(27) "Versprechen," "Verhören," ("Verlesen")
(28) "Komplexvertreter" (Complex-surrogate)
(29) Translations
(30) Interjections or Single Letters

II. *Quantitative*

(1) Time

III. *Physiological*

(1) Psychogalvanic Reflex
(2) Electro-motor Heart Flow
(3) Pulse
(4) Respiration
(5) Blood Pressure
(6) Involuntary Movements, or Tremors of the Hands or the Limbs
(7) Ataxiagraph (Involuntary Bodily Sway)
(8) Knee-jerk
(9) Lifting Ability of the Finger (Ergograph)
(10 Tapping Test
(11) Strength of Grip
(12) Facial Expression (Reddening, etc.)
(13) Tone of Voice in Response
(14) Ability to Concentrate (Disturbances of Attention)
(15) General Conduct and Behavior (Coughing, Clearing the Throat, etc.)

KENT-ROSANOFF ASSOCIATION SERIES

1. table
2. dark
3. music
4. sickness
5. man
6. deep
7. soft
8. eating
9. mountain
10. house
11. block
12. mutton
13. comfort
14. hand
15. short
16. fruit
17. butterfly
18. smooth
19. command
20. chair
21. sweet
22. whistle
23. woman
24. cold
25. slow
26. wish
27. river
28. white
29. beautiful
30. window
31. rough
32. citizen
33. foot
34. spider
35. needle
36. red
37. sleep
38. anger
39. carpet
40. girl
41. high
42. working
43. sour
44. earth
45. trouble
46. soldier
47. cabbage
48. hard
49. eagle
50. stomach
51. stem
52. lamp
53. dream
54. yellow
55. bread
56. justice
57. boy
58. light
59. health
60. bible
61. memory
62. sheep
63. bath
64. cottage
65. swift
66 blue
67. hungry
68. priest
69. ocean
70. head
71. stove
72. long
73. religion
74. whiskey
75. child
76. bitter
77. hammer
78. thirsty
79. city
80. square
81. butter
82. doctor
83. loud
84. thief
85. lion
86. joy
87. bed
88. heavy
89. tobacco
90. baby
91. moon
92. scissors
93. quiet
94. green
95. salt
96. street
97. king
98. cheese
99. blossom
100. afraid

JUNG ASSOCIATION SERIES

1. head
2. green
3. water
4. to sing
5. dead
6. long
7. ship
8. to pay
9. window
10. friendly
11. to cook
12. to ask
13. cold
14. stem
15. to dance
16. village
17. lake
18. sick
19. pride
20. to cook
21. ink
22. angry
23. needle
24. to swim
25. voyage
26. blue
27. lamp
28. to sin
29. bread
30. rich
31. tree
32. to prick
33. pity
34. yellow
35. mountain
36. to die
37. salt
38. new
39. custom
40. to pray
41. money
42. foolish
43. pamphlet
44. despise
45. finger
46. expensive
47. bird
48. to fall
49. book
50. unjust
51. frog
52. to part
53. hunger
54. white
55. child
56. to take care
57. lead pencil
58. sad
59. plum
60. to marry
61. house
62. dear
63. glass
64. to quarrel
65. fur
66. big
67. carrot
68. to paint
69. part
70. old
71. flower
72. to beat
73. box
74. wild
75. family
76. to wash
77. cow
78. friend
79. luck
80. lie
81. deportment
82. narrow
83. brother
84. to fear
85. stork
86. false
87. anxiety
88. to kiss
89. bride
90. pure
91. door
92. to choose
93. hay
94. contented
95. ridicule
96. to sleep
97. month
98. nice
99. woman
100. to abuse

JUNG'S ASSOCIATION SERIES AS MODIFIED BY WHITE

1. head	41. volume	81. brother
2. green	42. to despise	82. to harm
3. water	43. teeth	83. stork
4. to prick	44. correct	84. false
5. angel	45. crowd	85. anxiety
6. long	46. book	86. to kiss
7. ship	47. unjust	87. fire
8. to plough	48. frog	88. dirty
9. wool	49. to cut	89. door
10. friendly	50. hunger	90. to choose
11. table	51. white	91. hay
12. to carry	52. ring	92. quiet
13. insolent	53. to listen	93. scorn
14. to dance	54. pencil	94. to sleep
15. lake	55. woods	95. month
16. sick	56. apple	96. colored
17. proud	57. to meet	97. dog
18. to boil	58. low	98. to talk
19. ink	59. love	99. carriage
20. angry	60. glass	100. sky
21. needle	61. to quarrel	101. straw
22. to swim	62. goat	102. baby
23. journey	63. large	103. to lie
24. blue	64. potato	104. blood
25. bread	65. to paint	105. duty
26. to threaten	66. part	106. bed
27. rich	67. old	107. to rent
28. lamp	68. flower	108. sorrow
29. tree	69. to strike	109. mirror
30. to sing	70. box	110. prison
31. sympathy	71. wild	111. knee
32. yellow	72. bright	112. to live
33. mountain	73. family	113. change
34. to play	74. to wash	114. barn
35. sail	75. cow	115. snake
36. new	76. stranger	116. to uncover
37. custom	77. luck	117. policeman
38. to ride	78. to tell	118. wagon
39. wall	79. hesitation	119. judge
40. stupid	80. narrow	120. night

Other words may be interspersed if significant.

BOOK NOTES

Canestrini, Silvio. Ueber das Sinnesleben des Neugeborenen. Monographien aus dem Gesamtgebiete der Neurologie und Psychiatrie. Herausgegeben von A. ALZHEIMER, Breslau and Lawandowsky, Berlin. Berlin, Springer, 1913. 104 p.

The author of this monograph has attempted to study the sense development and reactions of the newborn child in waking and sleeping condition by a more exact method than has usually hitherto been used. The method employed consisted in testing the cerebral reactions of the child to various sensory stimuli by adjusting a specially devised apparatus, a modification of the Marey pneumograph, to the fontanelle of the child thus testing the cerebral pulse directly with simultaneous records of breathing. For the subjects of his experiments he chose infants of the age of one to fourteen days, selecting only those who had large and pulsating fontanelles so that the brain pulse and variations in the volume of the brain would be sufficiently pronounced to give graphic results. Altogether about 70 infants were studied and over 700 separate experiments were made. Different stimuli for the five different senses were employed, and the tests were made both in sleeping and waking condition, and the emotional condition of the child studied also.

The results of Canestrini's experiments in part corroborate and in part modify the results found by Kussmaul, Genzmer, Preyer and others who have studied the development of infants. Only in the sense of taste does the newborn child show a strikingly complete development and stands only a little below adult animals. As regards smell the human infant is far below newborn dogs and cats. The difference between the infant and the animal is still more striking when we consider the function of motility in general and certain psychic performances.

Among the most important results of Canestrini's own experiments are the following: The special tests of reaction to various sensory stimuli by the fontanelle method show that in the infant the sense of taste gives the most developed reactions, next perhaps are the reactions of the organ of hearing, no child being found among the 70 tested who did not react to acoustic impressions. From the day of birth on, light stimuli of definite intensity clearly influenced the breathing and the brain curve. The sense of touch showed strikingly slight reaction to pain stimuli and little excitability of the infants' nervous system to the electrical current. The strongest and promptest reaction occurred for stimuli of cold, which caused acceleration of breathing, increase of the brain volume, motor disturbances, but no regular change of the pulse frequency. The sense of smell showed the least development, as suggested by the author probably because an atrophy of this sense has already occurred.

This objective method which has been used also by Bechterew promises to give important results in case of children whose skulls are sufficiently metopic to allow the successful use of it.

W. H. B.

Psychologie der frühen Kindheit. Von WILLIAM STERN. Leipzig, 1914. 360 p.

Educators and psychogeneticists have long wanted a psychology of the early years of infancy and childhood. Here we have, so far as we know, the first attempt to furnish such a psychology, which follows certain main lines of interest from birth to the age of six years. The author begins with very general considerations about methods of child psychology, psychic developments, convergence, etc. He then takes up the speechless age, discusses its development of motive, the beginning of play organization, conquest of space memory, the activity of the Gemüth, etc. In the next part he discusses the development of speech, its four stages and beginnings, the end and composition of child language and its content, the factors and chief epochs. He then discusses the contemplation of pictures; then in successive sections, memory, fancy, play, forms of childish thought, the life of the soul and Gemüth, fear, aesthetic sensibility, feeling and treatment toward others, the effect of punishment, etc.

Probleme der Mystik und ihrer Symbolik. Von HERBERT SILBERER. Wien und Leipzig, Hugo Heller & Co., 1914. 275 p.

After an introductory part treating of dreams and interpretation of Märchen, comes second, an analytic part treating the psychoanalytic meaning of the parabola, alchemy, hermetic art, crossing of races and free masonry, and the problem of manifold interpretation. The third, synthetic part deals with introversion and rebirth, first sensationalism and introversion, second, the consequences of the latter, and third, regeneration. Finally the writer discusses the mystic goal and the royal art. There is a copious literature and a convenient index.

The Great Society. A Psychological Analysis. By GRAHAM WALLAS. New York, Macmillan Co., 1914. 369 p.

This work treats of social psychology, instinct, intelligence, philosophy and environment, fear, pleasure, pain, happiness, the psychology of the crowd, love and hate, thought, the organization of thought and will, and the philosophy of absence.

Die Mystikerin Margaretha Ebner (c. 1291-1351). Von Dr. LUDWIG ZOEPF. Verlag B. G. Teubner, Leipzig und Berlin, 1914. 177. p.

This is a very interesting study of a mediaeval mystic and of her time. She was born in 1291 and her mystic period began in 1335, when she had a very vivid picture of the sufferings of Jesus and became mystically united with him. Then follows an account of her various dreams and visions, and finally her relations to her own period, to the cloister, the outer world, etc. The work is done with great thoroughness and there is a long list of authors.

The Elements of Psychology. By DAVID R. MAJOR. R. G. Adams & Co., Columbus, Ohio, 1914. 403 p.

In the present revision of this text two years after it first appeared we are told that "many paragraphs and sections have been rewritten. A number of new paragraphs have been added, two new figures have been introduced, and the topics in several of the chapters have been rearranged."

The Vital Law. By EDWIN M. JOHNSON. Vital Law Publishing Company, Kansas City & London, 1914.

Vol. 1. The Force That Operates Every Organism. 301 p.
Vol. 2. How Mind Causes the Force of Organism to Heal or Destroy. 302 p.
Vol. 3. How Mind Causes Chemical, Physical and Vital Changes. 291 p.

These three well printed volumes deal with such topics as the following: the force that works from within; the element of force; life, force and the body; hearing and seeing vital truths; life to them in the shadow of death; mind causes vital physical changes; the tongue heard and answered; suggestive therapeutics and the vital law; thy faith; physical, chemical and vital laws; the languages we interpret and speak; physiology; sundry links of evidence; scriptural guides; the vital law. This work is designed to be practical rather than theoretical, intuitive rather than erudite, insightful rather than scientific. One would hardly expect in a work of this kind that the author would be aware of the latest results of science where they touch his field; yet on such topics as hypnotism there are formal quotation from various modern authors; on the cell, quotation from E. V. Wilson; Burke, Origin of Life; on the senses Herter is quoted, and many other writers including scripture.

Psychology. General and Applied. By HUGO MÜNSTERBERG. New York & London. D. Appleton & Co., 1914. 470 p.

This seems to be the twenty-first volume of this prolific writer. One of his first books was on psychology and life, in which the argument was that they had no connection. This is designed to show almost the exact opposite. He says that the plan and aim of this book is very different from all the bewildering variety of other textbooks in that it includes applied as well as general psychology. "Hitherto textbooks have been confined to theoretical study. The time seems ripe for bringing the psychologist's work into full contact with the practical efforts of civilization." Moreover, we are told that this book is unique in that it includes social psychology. In the introduction he discusses aims, then casual psychology, its principles, and the elementary, group and social processes.

Then on page 285 begins what he calls purposive psychology, viz., individual and social experiences. Book three, beginning page 331, is called applied psychology, psycho-technical science, etc. Our own impression is that it is this section that is weakest and particularly the medical psychology which the author, who is believed to be a physician, so ignores.

The Psychological Monographs. Edited by CARL E. SEASHORE. Psychological Review Co., Princeton, N. J. & Lancaster, Pa., June, 1914. University of Iowa Studies in Psychology, No. VI. 177 p.

This is a study in accuracy of the voice in simple pitch singing by Walter R. Miles, the effect of training in pitch discrimination by F. O. Smith, the lower limit of tonality by T. F. Vance, who also has a paper on variation in pitch discrimination within the tonal range, and finally there is a study by R. M. Stewart on the effect of intensity and order on the apparent pitch of tones in the middle range, and a paper by Clara Hancock on the effect of intensity of sound upon the pitch of the low tones.

Die Philosophie der Gegenwart. Herausgegeben von Dr. ARNOLD RUGE. Heidelberg, Weiss'sche Universitätsbuchhandlung, 1914. 324 p.

This fourth volume contains titles from 1, The American Journal of Psychology, to 3531, Ziese, Wachstum und Entwicklung, and is well indexed.

Berlin in Wissenschaft und Kunst. Ein Akademisches Auskunftsbuch nebst Angaben über Akademische Berufe. Von Prof. Dr. WILHELM PASZKOWSKI. Berlin, Weidmannsche Buchhandlung, 1910. 336 p.

Die wirklichen Tatsachen der reinen Erfahrung, eine Kritik der Zeit. Von FRANZ SELETY. Leipzig, Johann Ambrosius Barth, 1913. 15 p. Sonder-Abdruck aus der Zeitschrift für Philosophie und philosophische Kritik.

Fortschritte der Psychologie und ihrer Anwendungen. Herausgegeben von Dr. KARL MARBE. III. Band—I. Heft. Leipzig, B. G. Teubner, April, 1914. 42 p. (Zur Psychologie des Denkens.)

Fortschritte der Psychologie und ihrer Anwendungen. Herausgegeben von Dr. KARL MARBE. II. Band—VI. Heft. Leipzig, B. G. Teubner, April, 1914. p. 322-371.

The Thirteenth Yearbook of the National Society for the Study of Education. Part II, Plans for organizing school surveys with a summary of typical school surveys. By H. L. SMITH & CHARLES H. JUDD. Chicago, University of Chicago Press, 1914. 85 p.

Wort und Seele: eine Untersuchung über die Gesetze in der Dichtung. Von HELLMUTH FALKENFELD. Leipzig. Felix Meiner Verlag, 1914. 132 p.

A BIBLIOGRAPHY OF THE SCIENTIFIC WRITINGS OF WILHELM WUNDT

By E. B. Titchener and W. S. Foster

(*Sixth Supplementary List*)

1901

(6) *Lectures on Human and Animal Psychology*, translated by J. E. Creighton and E. B. Titchener. Third edition. Large 8vo. London, Swan Sonnenschein & Co.; New York, The Macmillan Co. pp. x., 459.

1913

(5) *Einführung in die Psychologie.* Neue Auflage. 8vo. Leipzig, R. Voigtländer. pp. viii., 129. [See 1911 (9).]

1914

(1) *Zur Frage der umkehrbaren perspektivischen Täuschungen.* Psychologischt Studien, IX., Heft 3 und 4, Jan., 272-277.

(2) *Völkerpsychologie.* Eine Untersuchung der Entwicklungsgesetze von Sprache, Mythus und Sitte. Vol. v. Mythus und Religion, zweiter Teil. Zweite, neu bearbeitete Auflage. Large 8vo. Leipzig, A. Kröner. pp. xiii., 494. [See 1910 (6).]

(3) *Einleitung in die Philosophie.* Sechste Auflage. Mit einem Anhang, etc. Large 8vo. Leipzig, A. Kröner. pp. xviii., 448.

(4) *Sinnliche und übersinnliche Welt.* Large 8vo. Leipzig, A. Kröner. pp. viii., 423.

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Pub by G. G. F. Lange
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